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NOVEMBER 1898

THE COMPARATIVE MORPHOLOGY OF THE PISTILS OF THE RANUNCULACEÆ, ALISMACEÆ, AND ROSACEÆ.[1]

ERNST A. BESSEY.

(WITH PLATE XXV)

RANUNCULACEÆ.

THERE are two types of pistil present in this family. In the first there is but a single ovule in each pistil; in a specialized form of this type there are, besides the one principal ovule, two to six rudimentary ovules subsequently developed, but never reaching maturity. The second type consists of those pistils which have two to many ovules, all or nearly all reaching maturity. Pistils of the first type are found in the Ranunculeæ, Anemoneæ, and Clematideæ, and of the second type in the Helleboreæ and Paeonieæ.

The species studied to determine the mode of development of the pistils were the following: *Ranunculus abortivus* L., *R. eremogenes* Greene, *R. delphinifolius* Torr., *R. ovalis* Raf., *R. glaberrimus?* Hook., and *Myosurus minimus* L., all representing the strictly uniovulate type; and *Anemone Caroliniana* Walt., *A. cylindrica* Gray, *A. Canadensis* L., *Pulsatilla hirsutissima* (Pursh) Britt., and *Clematis ligusticifolia* Nutt., representing the uniovulate type where rudimentary ovules are developed. For the study

[1] A thesis for the degree of Master of Arts, in The University of Nebraska, 1898.

of the multiovulate type, use was made of *Delphinium Carolinianum* Walt., and *Caltha leptosepala* DC.

RANUNCULUS ABORTIVUS. The pistil first makes its appearance as a slight rounded projection from the surface of the then small receptacle. This projection enlarges, as does the receptacle, until it is almost hemispherical. It then begins to elongate, and during this process a second, rounded projection appears in the axil of this as yet only slightly developed carpellary leaf (*fig. 1*). The second rounded mass of cells is produced as a result of the rapid division of the hypodermal cells, and is not epidermal, but is covered with epidermis. At this time a cross-section of the pistil shows that the upper side is slightly flattened. This flattening becomes more pronounced until, in a short time, the pistil is seen to be slightly concave above, *i. e.*, the edges of the carpellary leaf are beginning to fold around, eventually to meet to form a closed pistil (*fig. 2*).

In addition to this lateral folding, the outer part of the pistil soon begins to bend upward, until its apex, which was at first directed at right angles to the surface of the receptacle, now points in a direction parallel to it. The lateral folding, also, continues, nearly closing the upper part of the pistil (*figs. 3, 4*). In the meantime the axillary mass of cells has been growing, especially at the side towards the receptacle, causing its apex to turn away from the receptacle and down into the cavity in the upper part of the pistil, which has been bending upward, and towards the receptacle. It has now become possible to distinguish two parts in the axillary mass of cells; a thicker basal part (which I will call the "axillary placenta," since it arises in the axil of the carpellary leaf) and a slender apical part, the ovule, which bends down between the laminae and thus into the hollow of the pistil (*figs. 5, 6*). The axillary placenta itself is really not within the pistil, but forms part of the wall on the ventral side. The laminae of the pistil extend to it and are continuous with its outer layers of cells, and extend from it to the apex of the carpellary leaf, which has bent around almost in a semicircle. When these laminae finally come together to close the

pistil, they curve in over the top of the axillary placenta, forming a forked suture shaped like an inverted letter Y.

While the carpel has thus been curving upward, the growing nucellus has been bending downward, the former describing an arc of 180°, while the latter passes through only 120°. A short time before this stage is reached the archesporial cell is differentiated, the exact time being very variable. The wall of the pistil furthest from the receptacle now elongates considerably, with the result that the longest axis of the pistil instead of being, as at first, at right angles to the surface of the receptacle, is now parallel to it. The ovule still continues to bend until it, too, lies in the main axis of the pistil, but with the micropyle pointing down. The last small opening of the pistil is now closed by the meeting of the edges of the laminae. It is the line of meeting of the laminae with the upper side of the axillary placenta, or in other words, one of the arms of the inverted Y-shaped suture, that shows so distinctly in all median or almost median sections of the pistil (*fig. 8, a*).

The main fibrovascular bundle supplying the pistil divides just after entering it. One branch passes around in the median line in a position corresponding to the bundle of the mid-rib of a leaf. The other passes up into the axillary placenta, through the funiculus and into the base of the nucellus, also in the median line (*fig. 8*). Later other branches run to the side walls of the pistil.

RANUNCULUS EREMOGENES. The development of the pistil in this species is almost identical with that in *R. abortivus*. The pistil begins as a rounded outgrowth from the receptacle (*fig. 9, a*), which is more developed in this species at this stage, than in the preceding. Immediately above the base of this outgrowth there arises another, eventually to become the ovule. This is shown in *fig. 9*, at *b*, which is a rudimentary pistil, with the still more rudimentary ovule three or four cells higher. The pistil flattens dorsiventrally and the edges begin to fold together, while the apex also curves upward. The axillary papilla at the same time elongates and the distinction of ovule and placenta is

made. The ovule bends down into the space between the laminae of the carpel. The single integument now begins to make its appearance, and the archesporium becomes visible as a specialized cell. By this time the ovule has described an arc of 120° from the position held by the axillary papilla when it first appeared. The development is now so rapid that by the time the archesporium has divided into two cells and each is beginning to divide again, the ovule has bent 30° more (*fig. 10*), and at the completion of the division has bent another 30°. At the same time the apex of the carpel has passed through an arc of 180°, and the main axis of the pistil has become parallel to that of the receptacle. A noteworthy fact in connection with the development of the archesporium is that the two megaspores nearest to the micropyle lie in a line nearly at right angles to the main axis of the nucellus (*fig. 10*). Soon after this stage is reached the pistil becomes closed through the meeting of the edges of the laminae. A front view of a nearly mature pistil shows that in this species, as in *R. abortivus*, the suture is shaped like an inverted Y (*fig. 19*).

Ranunculus ovalis, R., *glaberrimus?* and R. *delphinifolius* show in their later stages the same structure as described above, indicating that they probably have a similar course of development.

MYOSURUS MINIMUS. This species has a long, narrow receptacle, in strong contrast to the short hemispherical one of Ranunculus. On it is shown more vividly what is apparent to a slight degree on the receptacle of Ranunculus, viz., the acropetal development of the pistils. In Ranunculus the difference in age of the pistils on the different parts of the receptacle is only slight, and soon disappears. On the other hand, in Myosurus, even when the pistils on the lower part of the receptacle are well developed, others are just appearing at the top. As in the preceding genus, the pistil appears as a slight papilla on the surface of the receptacle. As it elongates, its apex is directed slightly downwards. On the upper side of the pistil, next to the receptacle, is then developed an axillary papilla whose axis, at first, forms an angle of about 35° with the surface of the receptacle,

while the apex of the pistil is directed so as to form an angle of about 90° with the axis of this papilla (*fig. 11*). Even at this stage the outer part of the pistil is flattened above (*figs. 12, 13*). This flattening progresses until a longitudinal groove is formed in the upper surface of the carpellary leaf, extending back to the axillary placenta. The apex of the carpel now begins to bend upward, while the ovule begins to grow downward. By the time that the ovule has bent 45° from its original position, the archesporium appears. The outer part of the pistil has also changed its direction by 45°, thus bringing the ovule partly within the cavity formed by the laminae which connect the axillary placenta with the apex of the carpel (*fig. 14*). At the time that the first traces of the single integument appear, the archesporium has divided into two cells and the ovule points directly down, *i. e.*, in its curving it has described an arc of about 145°. The apex of the carpel has in the same time described an arc of only 125°, so that it lies parallel to the receptacle (*fig. 15*). For some time further the pistil does not change much except in size. The ovule, on the other hand, is active in its changes. By the time that the megaspore furthest from the micropyle has by its enlargement destroyed the others (two or three in number), the ovule has curved 90° more (*figs. 16, 17*). This process continues until at the time that the embryo sac is ready for fertilization the ovule lies with its axis parallel to that of the receptacle, a change in direction of about 325° (*fig. 18*). To accommodate the ovule thus bent upon itself the lower part of the pistil elongates somewhat, so that the fibrovascular bundle of the median line of the carpel, after leaving the receptacle and giving its branch to the ovule, passes first downward, then outward, and finally upward. The bundle going to the ovule passes first upward, then outward, then downward, and finally inward to the base of the nucellus. From this time on until the seeds drop, the position of the nucellus remains the same, so that by making longitudinal sections of the flower, it is easy to obtain longitudinal median sections of all the ovules, from one hundred to two hundred in number. As in Ranunculus, the

pistils are not entirely closed until a very short time before fertilization, and then in the same manner. The further development of the pistil after fertilization is, however, a little different in the two genera. In Myosurus, instead of enlarging rapidly so as to leave a large cavity which the ovule fills only in part, the pistil enlarges only as does the ovule, leaving no cavity. The walls, too, do not become stony, thus allowing (what is very difficult in Ranunculus) the study of the development of the embryo.

ANEMONE. In the first stages of the development of the pistils this genus resembles Myosurus very closely. In fact, the development throughout of the single large ovule is as in that genus (*figs. 20–23, 26*). A slight difference in the shape of the pistil is noticeable, in that the cavity is prolonged somewhat above the ovule. In *Anemone Caroliniana*, after the ovule has curved down into the cavity of the pistil, there appear on the edges of the laminae, which are now closing together, two projections. These increase in size, growing down into the cavity of the pistil above the first ovule. They remain merely few-celled papillae in this species, one on each lamina, the central cells resembling archesporial cells (*fig. 24*). This occurs also in other species of this genus, the papillae in some species often becoming well-marked, rudimentary ovules. This is so common that Baillon describes[2] Anemone as being provided with five ovules, four being aborted and one descending and fertile.

CLEMATIS LIGUSTICIFOLIA. The pistils in this species are even more elongated than in Anemone, and have the cavity correspondingly elongated above the ovule. Unfortunately, it was impossible to obtain the younger stages, but the close agreement of the older stages with those found in Anemone makes it practically certain that the course of development is the same. The mature ovule is situated exactly as in Myosurus and Anemone. Like the latter, however, on each side above the large ovule the lamina bears one or two rudimentary ovules which project into the space above it (*fig. 25*). The only dif-

[2] BAILLON: Mémoire sur la famille des Renonculacées. Adansonia 4: 50. 1864.

ference between this and *Anemone Caroliniana* is that the ovules are further developed, some of them in fact having embryo sacs with two or four nuclei. Guignard describes[3] and figures these accessory ovules in *Clematis cirrhosa* with embryo sacs containing two and four nuclei, showing conclusively their ovular nature. Some species of Anemone, too, have these accessory ovules developed to this extent, showing that in this there is no distinction between the two genera.

DELPHINIUM CAROLINIANUM. Owing to the ease with which the material could be obtained, this species was the one chiefly used in the study of the multiovulate type of pistil. *Caltha leptosepala* was used to corroborate the results obtained from the study of this species. It was evident from figures and descriptions of the pistils of this type, published elsewhere, that these two species give us typical examples, and it was accordingly decided that it would be unnecessary to make careful study of other species. Unfortunately it was impossible to obtain specimens of those genera with biovulate pistils, forming perhaps the transition from the uniovulate to the multiovulate genera. The pistils arise at the top of the nearly hemispherical receptacle. The stamens develop acropetally. The pistils do not show any signs of appearing until all the stamens have begun to develop. Each pistil first appears as a small conical papilla with rounded apex, and increases in size very rapidly. As this increase in size progresses, the ventral side begins to be hollowed out, until by the time that the pistil is a millimeter in height, and a little narrower than high, it has become closed by the meeting of the laminae (*figs. 27, 28*). Soon the ovules begin to make their appearance as small papillae on the inturned edges of the carpellary leaf. These increase rapidly in number and size until the edges of the laminae of the pistil are occupied entirely by horizontally growing ovules (*fig. 29*). In Delphinium the ovules arise opposite to each other, but later, owing to the crowding due to their growth in size, they become alter-

[3] GUIGNARD, LEON: Récherches sur le sac embryonnaire des phanérogames angiospermes. Ann. Sci. Nat. Bot. VI. **13**: 163. *pl. 5*. 1882.

nate. The lowest ovule, having no ovule below to sustain it, may descend into the hollow at the bottom of the pistil.

In *Caltha leptosepala* the ovules are mostly alternate, and are fewer in number than in the pistils of Delphinium, the difference being apparently compensated by the greater number of pistils in the former. The only other difference worthy of mention is that the ovules of Caltha are two-coated, while those of Delphinium have only one integument (*fig. 31*).

ALISMACEÆ.

The two genera studied were Sagittaria and Alisma. These are in the main, alike so far as the development of the pistils is cerned, for the slight differences that do occur are easily explicable by the difference in number of the pistils, involving their relations to each other and to the receptacle. Thus in *Alisma Plantago aquatica* L. there is but a single whorl of pistils, while in *Sagittaria latifolia* Willd. the ovules are very numerous and arranged spirally over the whole surface of the receptacle.

SAGITTARIA LATIFOLIA. In this plant, as in Myosurus, the pistils are developed acropetally. Each pistil makes its appearance as a papilla on the side or summit of the spherical receptacle. As this papilla enlarges it grows so as to leave a hollow on the upper side. In its axil there now appears a second papilla, which grows out into the space between the laminae of the pistil, which has now become somewhat curved. As these laminae increase in width they surround the ovule entirely except the very slightly developed "axillary placenta." As a result of this the ovule appears to arise from the floor of the pistil, as indeed some descriptions aver (*figs. 33–35*). While the pistil has been thus developing, the ovule has not remained unchanged. It has increased in length, and about half way from base to apex makes a sudden turn, at which place the two integuments arise. The ovule continues to bend upon the funiculus until by the time that the integuments have reached the apex of the nucellus the latter lies parallel to the surface of the receptacle, with its apex pointed away from the apex of the receptacle (*fig.*

36). Within a very short time the position of the ovule becomes permanent, with the apex of the nucellus directed towards the receptacle (*fig. 37*). Subsequent changes are mostly those in size and such modifications of shape as are caused by the pressure of the surrounding pistils.

ALISMA PLANTAGO AQUATICA. In the very young flowers of this species the receptacle is much broader above than below, and has a rounded top. It is from the narrower basal part that the stamens arise, while the pistils are produced at the edge where the receptacle is widest. They appear as projections, at first small, later larger (*fig. 38*). This gives the receptacle, viewed from above, the appearance of a toothed wheel. The receptacle grows rapidly in height, as do the apex and sides of each pistil, thus forming a hollow in the upper side of each (*fig. 39*). Into this rapidly deepening cavity, there pushes out from the receptacle a rounded mass of cells (*fig. 40*). The apical part of the pistil grows very rapidly until the laminae connecting it with the receptacle at each side of the ovular outgrowth are in such a position that their edges are nearly vertical. The ovule continues to elongate and curve towards the bottom of the pistil, eventually gaining a position in which its apex is directed downwards. During this process the nucellus has become differentiated and the two integuments have appeared. The funiculus has also been clearly distinguished (*figs. 41, 42, 43*). Up to the time of fertilization there has been no organic connection between the edges of the two laminae, although for a little while they have been in contact for a part of their distance. At the time of pollination there is still an opening between the laminae at the bottom of the line of meeting. This is due to the fact that the laminae arise with enough distance between them to allow for the formation of the ovule. Now, when their margins approach each other they are separated furthest at the bottom and require a longer time to come fully together (*fig. 44*). In the mature pistil the funiculus is long and ascending, carrying the ovule well up into the cavity of the pistil. In the young pistil the funiculus is short, and it is

only as the pistil grows that the funiculus also increases in length.

ROSACEÆ.

This family contains representatives of many types of flower-structure. Of these types the Potentilleæ have been regarded hitherto as the simplest. In this tribe the pistils are very numerous, on a rounded receptacle, which is expanded below into a shallow cup, on whose edge are borne the numerous free stamens, the petals and the sepals. In Fragaria and Potentilla each pistil is uniovulate, while in Geum it is biovulate. As a rule throughout the family the pistils are biovulate, and in some genera even multiovulate. The only genera studied as representatives of this family were Potentilla and Fragaria, it being the aim to determine whether the remarkable similarity that these show to Ranunculus is also found in the processes of development of the parts of the flower.

POTENTILLA MONSPELIENSIS L. The pistils first appear, as in Ranunculus, as small papillae on the surface of the pistil-bearing part of the receptacle. The first to appear are at the base and the others arise successively towards the top of the receptacle (*fig. 45*). As the pistils enlarge they become hollowed out above. A comparatively small opening is produced on the upper side of the pistil (*fig. 46*), which is made still narrower by the thickening of the edges of the laminae for about half the distance from base to apex. This thickening is sometimes accompanied by a more active growth in width of that part of each lamina, so that viewed from the side it appears as a rounded lobe, as shown in *fig. 47*, where the dotted line shows the more usual form. From one of these thickened edges or lobes a small papilla begins to grow inward and downward, later turning upward again. This is the ovule. It is at first lateral in its position, but the lamina to which it is attached grows more rapidly than the part opposite, so that the ovule finally occupies a median position (*fig. 48*). The ovule, when the pistil is ready for pollination, is anatropous, with the funiculus on the ventral

side of the pistil, instead of on the dorsal as in Myosurus. The ovule has but a single integument, and in the large size of its nucellus, as well as in its position in the pistil, much resembles that of Ranunculus (*fig. 50*).

FRAGARIA VIRGINIANA. The development of the pistil in this species is practically identical with that in the preceding. The only important difference is that the line in which the laminae meet is shorter, so that the style arises from well down on the front of the pistil. In this species is also found what probably indicates an advance in development beyond that shown in Potentilla, namely, quite often a pistil contains two ovules instead of one. This doubling is acomplished by the formation of one ovule on each of the thickened laminae, instead of on one only. Possibly this is the way in which the uniovulate genera, like Potentilla, have developed into the typical biovulate genera of the family (*figs. 51–53*).

GENERAL DISCUSSION.

A comparison of the structures exhibited by the pistil in these three families shows that each family includes genera with uniovulate as well as those with multiovulate pistils, and that the course of development of the uniovulate pistils is very similar in the three families, although in Potentilla and Fragaria it has been somewhat modified.

It has been shown above that in Ranunculus the first sign of the ovule is the growth of a mass of cells in the axil of the developing carpel. The carpel elongates and becomes hollowed above by the upward growth of the laminae, which do not grow up over the axillary mass of cells, but rather extend from it on each side to the apex of the carpel. By the elongation of the distal part of the axillary body the ovule is formed, and curves down into the cavity of the pistil, while the proximal part remains in its original position, growing only in height and thickness. The laminae which extend from this body (called above the "axillary placenta") to the apex of the carpel, now approach each other at their edges, and meet in the median line, thus completely

closing the cavity of the pistil. The suture along which the laminae meet is like an inverted Y, for before they close they are separated at the bottom by the axillary placenta (see *fig. 19, R. eremogenes*).

If we now compare with this the conditions found in Potentilla and Fragaria, we see the following modifications. There is no axillary mass of cells developed, for the ovules have their origin on the edge of one or the other lamina. Probably this originated as follows: in some plant whose ovules were borne as in Ranunculus, and in which the suture along which the laminae met formed an inverted Y, a variation appeared by which the axillary placenta lost its median position, one arm of the suture becoming elongated and the other shortened. This resulted in a placenta attached to one lamina and free from the other, which is precisely what we find in Potentilla. Even in Ranunculus it occasionally occurs that the axillary placenta is not strictly median but slightly shifted to one side or the other. This suggests that the mode of origin indicated above is not improbable.

In the uniovulate pistils of Fragaria as well as of Potentilla the ovule is borne sometimes on one lamina and sometimes on the other, being very variable in this respect. Under such conditions when neither lamina is especially modified for the production of ovules it is probable that sometimes an ovule might be borne on each lamina, as happens in Fragaria. It seems probable that it was by such a variation that the majority of the genera of the Rosaceæ became biovulate. When once each lamina began to be ovuliferous it would be but a short step to the condition in which several ovules are borne, instead of only one. In this way the multiovulate pistils may have arisen. Probably in this way, too, the multiovulate Ranunculaceæ were developed from the uniovulate Ranunculus, possibly through a biovulate form close to Callianthemum, or even Hydrastis.

From the description of their development as given above it must be evident that Sagittaria and Alisma are quite similar to Ranunculus. Of these two genera, however, Alisma is much

less like Ranunculus than is Sagittaria, for the ovule is hardly axillary with respect to the carpel, but arises from the receptacle, in this respect much resembling the origin of the sporangium of Selaginella. The condition found in Sagittaria is one about midway between that in Alisma and that in Ranunculus. In the latter the axillary placenta is in reality only an outgrowth from the receptacle, and this prepares us to find (as in the Alismaceæ) the ovule developed directly from the receptacle. In other cases, as in Potentilla, this axillary placenta loses its individuality by fusion with one of the laminæ of the carpel.

The presence of the accessory ovules in Anemone, Pulsatilla, Clematis, and other genera is difficult to explain. If it were not for the peculiar origin of the one ovule which reaches maturity, it might naturally be supposed that Anemone is descended from plants with multiovulate pistils. However, if this were the case it would be necessary to consider also that Ranunculus and Myosurus had a similar origin, which seems highly improbable in consideration of their close resemblance to the Alismaceæ, which show in other characters no signs of having had Anemone-like ancestors. Furthermore, there are no existing multiovulate Ranunculaceæ that seem to be as simple in other respects as Ranunculus, for their pistils are fewer in number and close much earlier, an evident unsimilarity to the theoretical pteridophytic ancestors of the angiosperms. Perhaps the best solution of the problem is the supposition that some plant of the Ranunculus or Myosurus type after the development of its first ovule varied so as to develop in the space above the ovule one or more accessory ovules which were unable to reach maturity. These accessory ovules being in the unoccupied upper part of the pistil out of the way of the large ovule, and yet protected by the carpel wall, would have no part in the struggle of the plant for existence, and so might persist. This would be the more likely to be true if this modification happened to occur in a plant which, owing to other modifications, was enabled to maintain itself against all enemies, and to be well distributed. This seems to have been the case here, for these accessory ovules are found in

those genera in which the ripe achenes are furnished with hairs to aid in their distribution. Evidently under such circumstances, where they occupy a neutral position they would persist although not yet functional.

The uniovulate types might be summed up as follows. These all represent a type of pistil in which an axillary structure appears, developing directly into the ovule in some cases, or in others forming an axillary placenta on which the ovule is borne, or in still others uniting with one lamina of the pistil and bearing at its summit an ovule.

The multiovulate types are not sufficiently different to require discussion beyond the statement that they are probably developed from a modification of the last mentioned case among the uniovulate pistils.

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Lincoln, Nebr.

EXPLANATION OF PLATE XXV.

NOTE.— All the figures were drawn by the author, by means of the camera lucida, with one or two exceptions, from sections 7 to 18μ in thickness, cut upon a Reinhold-Giltay microtome. Some of the material was fixed with 1 per cent. chromic acid solution, some in various platinic chloride mixtures, and the remainder in various osmic acid mixtures, imbedded in paraffin, sectioned, and mounted in Canada balsam. All sections were stained on the slide, many different stains being used. The sections were examined by means of Reichert's objective 8, and oculars 2 and 4. In making the drawings only the outer layer of cells or merely the outline is given.

When not otherwise stated all sections called "longitudinal" are median longitudinal sections.

The magnifications given are those of the drawings, which were reduced one-half in engraving.

Ranunculus abortivus L.

FIG. 1. Longitudinal section of a very young pistil. × 565.

FIG. 2. Cross section of a slightly older pistil. × 565.

FIG. 3. Longitudinal section of a pistil showing the axillary mass of cells. × 565.

FIG. 4. Cross section of a pistil from the same flower as *fig. 3*, in the line *a–a*. × 565.

FIG. 5. Longitudinal section of a pistil at the time of formation of the archesporium. × 565.

FIG. 6. Cross section of a pistil in the same flower as *fig. 5*, in the line *b–b*. × 565.

FIG. 7. Longitudinal section of a pistil at the time of formation of the four megaspores. × 224.

FIG. 8. Longitudinal section of fully developed pistil. × 250.

Ranunculus eremogenes Greene.

FIG. 9. Longitudinal section of two very young pistils. × 565.

FIG. 10. Longitudinal section of the ovule during the formation of the four megaspores. × 565.

Myosurus minimus L.

FIG. 11. Longitudinal section of a very young pistil. × 565.

FIG. 12. Cross section of apical part of a pistil from the same flower as *fig. 11*. × 565.

FIG. 13. Cross section of the basal part of a pistil from the same flower. × 565.

FIG. 14. Longitudinal section of a pistil at the time of the appearance of the archesporium. × 565.

FIG. 15. Longitudinal section of a pistil at a later stage than in the preceding figure. × 265.

FIG. 16. Longitudinal section of a pistil approaching maturity, but with the embryo-sac not far developed as yet. × 250.

FIG. 17. Longitudinal section of a pistil a little older. × 205.

FIG. 18. Longitudinal section of a mature pistil. × 125.

Ranunculus eremogenes Greene.

FIG. 19. Longitudinal ventral section of a pistil showing the formation of the suture shaped like an inverted Y. × 250.

Anemone cylindrica Gray.

FIG. 20. Longitudinal section of a young pistil, showing the beginning of the formation of the axillary body. × 540.

FIG. 21. Longitudinal section of the pistil at the time of the formation of the archesporium. × 535.

Anemone Caroliniana Walt.

FIG. 22. Longitudinal section of a pistil at the time of formation of the archesporium. × 250.

FIG. 23. Longitudinal section of a pistil with the embryo sac developed about halfway. × 120.

FIG. 24. Section of a pistil from the same flower as the preceding, in the line *c–c*. × 122.

Clematis ligusticifolia Nutt.

FIG. 25. Longitudinal section of a mature pistil, showing the accessory ovules. × 75.

Anemone Caroliniana Walt.

FIG. 26. Longitudinal ventral section showing the formation of the inverted Y-shaped suture. × 120.

Delphinium Carolinianum Walt..

FIG. 27. Longitudinal ventral section of a pistil before the appearance of the ovules. × 125.

FIG. 28. Cross section, in the line *d–d*, of a slightly older pistil, but with as yet no ovules. × 125.

FIG. 29. Cross section of a pistil showing ovules. × 75.

FIG. 30. Longitudinal ventral section of a pistil. × 75.

Caltha leptosepala DC.

FIG. 31. Cross section of a pistil ready for pollination. × 75.

Sagittaria latifolia Willd.

FIG. 32. Longitudinal section of an ovule with two archesporial cells. × 520.

FIG. 33. Longitudinal section of a pistil showing a single archesporial cell. × 540.

FIG. 34. Cross section of a pistil in the line *e–e* of *fig. 33*. × 525.

FIG. 35. Longitudinal section of a pistil a little further developed than the preceding. × 410.

FIG. 36. Longitudinal section of a pistil with an embryo sac containing two nuclei. × 155.

FIG. 37. Longitudinal section of a pistil ready for pollination. × 75.

Alisma Plantago aquatica L.

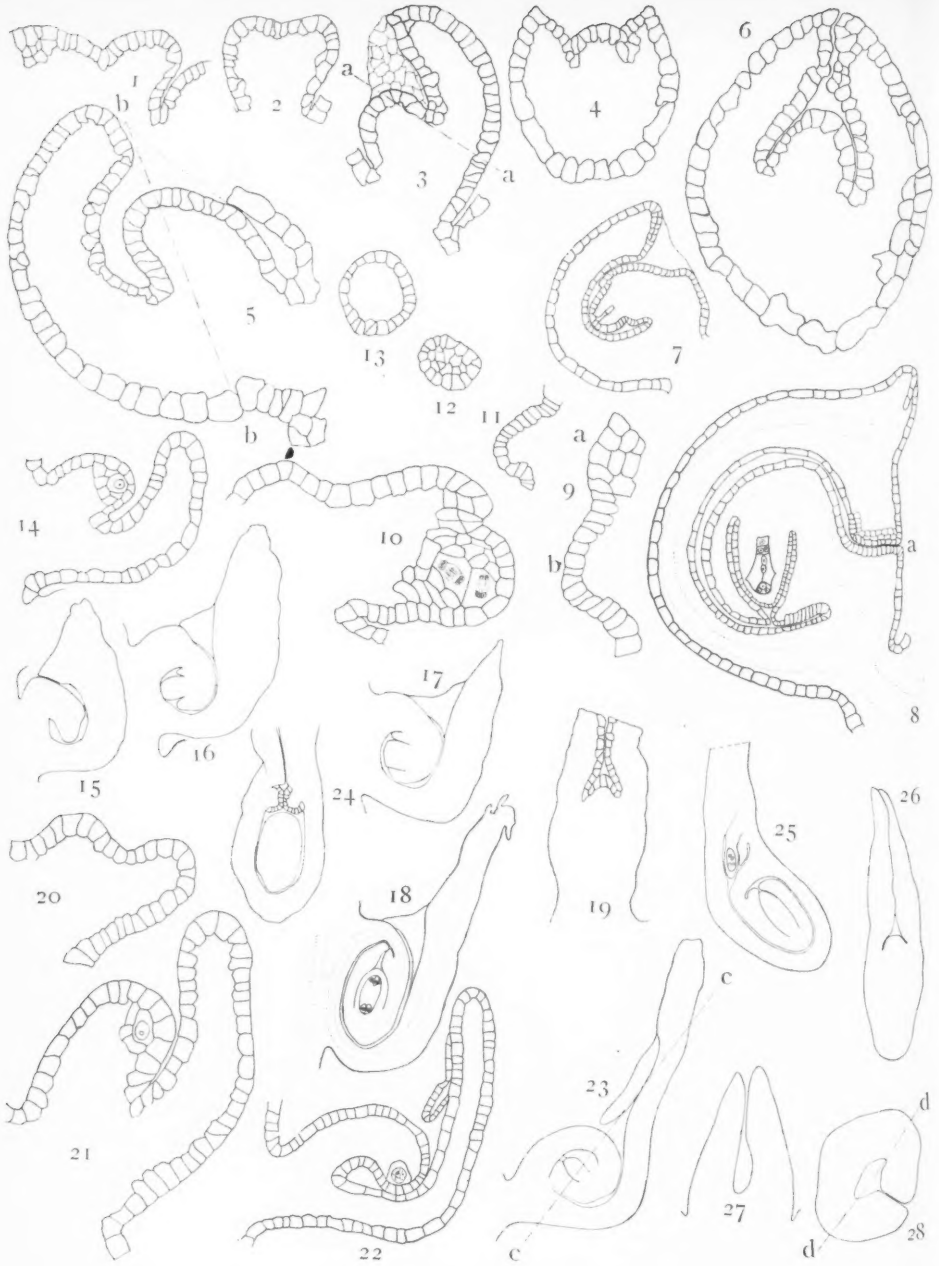
FIG. 38. Longitudinal section of a young flower showing the young pistil. The dotted line shows the level of the surface of the receptacle. × 155.

FIG. 39. Longitudinal ventral section of a pistil slightly older than the preceding. × 555.

FIG. 40. Longitudinal section of a young pistil in which the ovule is just beginning to appear. × 545.

FIG. 41. Longitudinal section of a pistil showing the archesporium. The section is slightly to one side of the median plane. × 555.

FIG. 42. Longitudinal section of a pistil at a further stage of development than the preceding. × 400.


1
b
2
a
3
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4
6
5
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12
11
7
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9
b
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17
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18
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c
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d
21
22
c
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29
31
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e
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39
38
36
b
43
44
a
b
8
40
41
42
26
47
46
48
49
51
50
52
d
53
45
28

FIG. 43. Longitudinal section of a pistil at the time of pollination. The shaded portion represents the part where the laminae have not yet met. × 75.

FIG. 44. Longitudinal ventral section of a pistil from the same flower as *fig. 43*, in the line *b–b*. × 125.

Potentilla Monspeliensis L.

FIG. 45. Longitudinal section through a young flower showing the developing pistils. × 145.

FIG. 46. Ventral view of a pistil from the flower shown in *fig. 45*, showing the opening. × 330.

FIG. 47. Lateral view of a pistil from the same flower, showing the lobe-like growth of the part of the lamina which bears the ovule. The dotted line shows the normal development. × 445.

FIG. 48. Ventral view of a pistil showing the excessive growth of the lamina which bears the ovule. The dotted line outlines the attachment of the ovule. × 255.

FIG. 49. Longitudinal section of a pistil shortly before pollination. × 255.

FIG. 50. Longitudinal section of a mature pistil. × 150.

Fragaria Virginiana Duchesne.

FIG. 51. Longitudinal section of a half-grown pistil. × 210.

FIG. 52. Longitudinal section of a pistil of about the same age as the preceding, but showing two ovules. × 295.

FIG. 53. Longitudinal section of a pistil ready for pollination. × 175.

THE EMBRYOLOGY OF ALYSSUM.[1]

LUMINA COTTON RIDDLE.

(WITH PLATES XXVI–XXVIII)

THE following study of *Alyssum macrocarpum* was begun late in October when a large and thrifty plant was brought into the greenhouse. Cuttings were made which began blooming about the holidays and a constant supply of material was thus furnished.

My original intention was to study *Capsella bursa-pastoris* and to verify or modify the account of its embryonic development, since Capsella has usually been taken as a type for the dicotyls. While Hanstein's method of studying the embryo by squeezing it from the ovule and staining with iodine might appear incapable of yielding any results of a detailed character, it seems nevertheless in his hands to have given rather accurate results.

The close relationship of Alyssum to Capsella, and the resemblance in embryonic development, which was evident from the first comparison with Hanstein's familiar figures, became a constant stimulus to careful and accurate investigation. While I am not wholly positive as to the invariability in the formation of certain portions of the young embryo plant, the most of my work points to a certain definite course of development, though there are sometimes remarkable variations.

My sincere thanks are due to Professor W. A. Kellerman and Mr. J. H. Schaffner for their continued encouragement and valuable suggestions.

METHODS.

Greenhouse plants did not seed profusely, probably because there were no insects present to assist in pollination. Before killing the material, the sepals, petals and stamens were removed,

[1] Contributions from the Botanical Laboratory of Ohio State University. V.

except from very young buds, to insure rapid penetration. Chrom-acetic acid, and a solution of corrosive sublimate, acetic acid, and 70 per cent. alcohol were the two fluids used. For general purposes the first seemed preferable, though satisfactory results were obtained from both.

The material was imbedded in paraffin and cut into sections 12 μ thick. It was difficult to orient the ovaries so as to get sections parallel to the plane of the embryo sac, since the ovule of Alyssum is campylotropous and the embryo sac soon becomes curved like a horseshoe nearly parallel to the septum of the silicle.

Anilin-safranin, alone or in combination with gentian violet, and sometimes with a third, orange gentian, was used in staining. Acid fuchsin and iron-alum-hæmatoxylin were also employed. The latter was very useful in bringing out early stages of the embryo sac, but it was not so good after endosperm was present. Combinations with anilin-safranin were most satisfactory for general purposes.

A Bausch & Lomb microscope with $\frac{2}{3}$, $\frac{1}{8}$ and $\frac{1}{12}$ objectives, and 2 and 1 inch oculars, was used, and drawings were made with the aid of a Bausch & Lomb camera.

DEVELOPMENT OF MACROSPORES AND EMBRYO SAC.

The archesporial cell (*fig. 1*) is hypodermal in origin and can be recognized in the nucellus before the two outer integuments have entirely surrounded it. The nucleus of the archesporial cell is larger than those in other cells and the contents are more granular. By a transverse division a tapetal cell (*fig. 2, t*) is cut off, and this apparently undergoes no further division. The macrospore mother cell, however, divides into four cells, three potential macrospores (*fig. 2, p*) and a vital macrospore (*fig. 2, m*), which is the lowest of the series and develops into the embryo sac, destroying the entire nucellus in its growth (*figs. 2–12*).

The two-celled embryo sac (*fig. 3*) is nearly straight, with nuclei at opposite extremities and a well marked vacuole in the

center. The embryo sac increases in width in the four-celled stage (*figs. 4, 5*), and when it has reached the eight-celled stage it has a decided curvature (*fig. 6*). Many of the eight-celled embryo-sacs were destroyed or rendered worthless for camera drawings because they were cut and scattered through too many sections. The one figured has been sectioned so as to cut off the antipodals. It is probable that one is looking at them from above rather than in side view, as the rest of the figure appears. During the last divisions of the embryo sac the tapetal cell disappears (*figs. 5, 6*).

Up to this point the nuclei are uniform in size, but after the conjugation of the polar nuclei the definitive nucleus is easily distinguished by reason of its superior size, the presence of numerous refractive particles in its large nucleolus, and the readiness with which it stains. The presence of refractive bodies is not peculiar to the nucleolus of the definitive nucleus alone, but is found in less degree in the endosperm nuclei and in the large nucleus of the basal suspensor cell. It may also be true of other nuclei, but is not noticeable on account of the diminutive size.

After the definitive nucleus is formed, the egg apparatus (*figs. 7–9*) is readily distinguished, but in the majority of cases the antipodals have entirely disappeared. They are either absorbed or destroyed by the progress of the embryo sac in its encroachment upon the lower part of the nucellus, crushing and crumpling them out of shape. In many cases the lower part of the nucellus is contorted and pushed aside by the advance of the embryo sac, indicating a remarkable degree of force exerted from within (*fig. 12*). Where remains of antipodals were found, that end of the embryo sac had evidently slipped between the nucellus and its integuments and had not been subjected to the usual ordeal (*figs. 35–36*).

The oosphere is well concealed by the synergids (*figs. 8, 9*) until after fertilization, when its nucleus descends into the lower part and the oospore (*fig. 10*) begins to elongate rapidly (*figs. 11, 12*). Up to this time the definitive nucleus remains

undivided, but after fertilization takes place endosperm is formed very rapidly and is especially abundant around the proembryo, obscuring it and making it difficult to distinguish the early stages of embryonic development if the section was cut diagonally.

DEVELOPMENT OF THE EMBRYO.

The first division in the proembryo is transverse and cuts off a basal suspensor cell which does not divide again (*fig. 13, a*). The cell at the end divides very soon into a terminal cell, a true embryo cell (*figs. 13, 14, c*) and an intermediate cell (*figs. 13, 14, b*). The terminal embryo cell divides by a longitudinal wall into two cells (*fig. 15, c*), and the two following longitudinal divisions at right angles to the first cut it into quadrants (*fig. 16, c*). The third division is a series of transverse walls in the cells of the quadrant and produces an octant (*fig. 17, c*).

The dermatogen is the first tissue to be differentiated and is cut off from the octant by a series of periclinal and anticlinal walls (*figs. 18, 19*). Division in the cells of the octant is evidently almost simultaneous, for I could find no instance where any one seemed to have priority in the process. The terminal embryo cell is now represented by two well developed tiers of cells (*figs. 19, 20, c, d*). In each tier, while the dermatogen divides radially, the inner cells undergo a longitudinal division.

Meanwhile the intermediate cell (*fig. 14, b*) has been dividing by a series of transverse walls, and in the cell next those derived from the terminal embryo cell (*fig. 19, c*), the wall has become somewhat rounded. This cell divides, first into two and then into four cells by longitudinal walls, making a quadrant. These divisions and the transverse divisions which follow and form the octant correspond to those which take place in the terminal embryo cell, and, since this cell develops into the lower part of the embryo, I shall henceforth refer to it as the basal embryo cell. The whole embryo is therefore developed from two original cells, a terminal embryo cell and a basal embryo cell, both of which first form quadrants by longitudinal walls, and subsequently octants by a series of transverse walls in

each of the quadrants. *Fig. 27* represents a peculiar variation or abnormality in the development of the region of the basal embryo cell.

To the inner cells of the tier *d*, *fig. 20*, one can refer the origin of plerome and periblem, the central cells forming the plerome and the single layer between this and the dermatogen giving rise to the periblem.

The transverse division begun in the dermatogen has extended throughout this tier *d* (*fig. 21*), and is followed by another radial division in the dermatogen, while a longitudinal division occurs in the innermost cells of tier *c* (*fig. 24*). A series of longitudinal walls also begins to appear in tier *d*, followed by irregular transverse divisions (*fig. 25*). The entire embryo is now developing rapidly. The basal embryo cell has undergone the third and transverse division, forming two tiers of four cells each next the suspensor (*fig. 25*, *f* and *g*). In the region where the cotyledons arise, diagonal division has occurred, while in the region of the stem tip it has been longitudinal. The plerome is quite distinct and is shaded in the figure.

A more advanced stage is shown in *fig. 28*. The cotyledons develop more rapidly and the embryo becomes obcordate (*figs. 29–31*). The plate of cells nearest the suspensor undergoes a series of transverse divisions as well as longitudinal ones. This division extends to some of the adjoining dermatogen cells (*fig. 30*), and gives rise to the calyptrogen, which becomes continuous with the dermatogen and by successive transverse divisions cuts off the root cap. The inner plate, by longitudinal divisions, contributes to that part of the root tip from which the periblem of the radicle is developed (*fig. 33*, *f*, *g*). Beyond this stage it is impossible to get central sections through the entire embryo. The cotyledons fold together and curve upward toward the antipodal region (*fig. 34*), and in the mature state the embryo fills the entire cavity of the embryo sac.

THE SUSPENSOR.

The basal suspensor cell never divides after the first transverse division of the oospore. The intermediate cell contributes

toward the suspensor by a series of transverse divisions, which at first apparently occur in acropetal order (*fig. 15*), but later stages seem to indicate intercalary division (*figs. 22, 23*). The number of cells is variable, some large embryos having only eight- or nine-celled suspensors, while in others the number of cells reaches fifteen. In a few cases, instead of the normal transverse division in the suspensor cells, a longitudinal division occurs, giving a peculiar abnormal appearance (*figs. 22, 26,* and *27*).

The function of the suspensor seems to be that of an absorbing organ, supplying nourishment to the rapidly growing embryo and serving the purpose of the root in mature plants. When stained with anilin-safranin or its combinations, the suspensor and the cells arising from the basal embryo cell stained much less deeply than those derived from the terminal embryo cell. This was of great advantage in clearly determining the origin of calyptrogen, root cap, and root tip.

The suspensor persists until the embryo is mature, although it becomes shriveled and apparently functionless some time before the resting period of the embryo is attained.

ENDOSPERM.

The definitive nucleus divides immediately after the formation of the oospore. The endosperm accumulates very rapidly in the region of the proembryo and often obscures it, especially in the early stages. Early in my work I concluded that endosperm was formed previous to fertilization, because I frequently found it when I could not distinguish any embryo. But later research showed that endosperm was not present until after the proembryo appeared; and, whenever found, remains of a badly sectioned embryo were evident. Several instances in which unfertilized oospheres were found in the same silicle with well developed embryos showed the definitive nucleus distinct and undivided in the shriveled embryo sac, and an entire absence of endosperm.

The endosperm forms a complete lining for the embryo sac (*fig. 12*), and then, passing through the well-known radiations,

forms cell walls. Some of the free cells accumulate in the antipodal region and form a peculiar thallus-like mass, which further assists in obscuring whatever remains of the antipodals might otherwise be found (*figs. 35–39*). This growth was for some time a puzzle as to its origin, whether the result of division of the antipodals, or a growth of endosperm arising from the first division of the definitive nucleus and cut off by a cell wall from other endosperm, as is the case in Sagittaria.[2] All doubt was dispelled when the remains of the antipodals were found (*figs. 35, 36*) while this thallus-like growth was in early stages of development. In many cases the appearance was so peculiar and the connection with all other endosperm so obscured, while the entire mass stained so similarly to the embryo, that it might easily deceive one as to its nature. Its function is not clearly evident, unless it may be considered as a reserve of food material after the suspensor ceases to supply nourishment.

COMPARISON WITH OTHER DICOTYLS.

Chamberlain[3] says the archesporial cell in Salix divides into a tapetal cell which sometimes gives rise to a tier of five or six cells but occasionally does not divide; and a macrospore mother cell which may or may not divide. If it does there is a potential macrospore which sometimes divides and a vital macrospore which develops without further preliminary division into the embryo sac.

In *Aster Novae Angliae*[4] he reports that after the expected division resulting in four cells, the lowest usually develops into the embryo sac.

Coulter[5] says of *Ranunculus multifidus:* "In no case was a primary tapetal cell cut off, the archesporial cell dividing directly into mother cells." Alyssum might therefore be considered more primitive in this respect than any of these except Salix, which shows a very unsettled state of affairs.

In the development of the embryo of Alyssum there is much

[2] Schaffner, BOT. GAZ. **23**: 252–273. 1897.
[3] BOT. GAZ. **23**: 147–179. 1897.
[4] BOT. GAZ. **20**: 205–212. 1895.
[5] BOT. GAZ. **25**: 73–88. 1898.

more regularity than in that of any other dicotyledonous embryo yet studied. Capsella is undoubtedly quite symmetrical and Alyssum comes very close to it in many respects. I regret that it was not possible for me to make comparisons directly with Hanstein's text and figures, as there is so much variation in the illustrations and reprints given in text-books.

In Vines's *Text-book of Botany*, p. 443, the terminal embryo cell is figured as dividing first transversely, then longitudinally, while the text reverses this. In Goebel's *Outlines*, p. 397, the figures represent the first division as longitudinal, the second as transverse, while the text gives the first and second as longitudinal and the transverse divisions as a third series. This corresponds to Alyssum. In Sachs's *Text-book*, p. 516, 1875, the figure is the same as in Goebel's, but in the text the third series of divisions is given as tangential and cutting off the dermatogen from the quadrants. Whether this statement is due to faulty translation or is so in the original German edition, I cannot say. It does not agree, however, with the German edition of 1882, for there it is distinctly stated in the text that the first three series of divisions are in three directions at right angles to each other, although in the explanation of *fig. 446, I–IV*, he gives the second series of divisions as transverse, and does not figure or mention the second longitudinal division.

Confusion likewise exists with regard to that portion of the embryo of Capsella which Hanstein designates as the "hypophysis." Its origin is uncertain. It is thought to arise from the last division of the suspensor cell; *i. e.*, the cell which gives rise to the greater part of the embryo remains dormant after the first division in the proembryo, while the suspensor cell continues to divide. The last cell arising thus contributes to the embryo. Chamberlain[6] doubts the accuracy of this theory, but thinks it probable that the terminal cell in which the first longitudinal division appears is wholly embryonic, while there may be a varying number of cells in the suspensors formed before this division occurs. This agrees with Alyssum. Hanstein's

[6] Bot. Gaz. **23**: 147–179. 1897.

"hypophysis," whatever its origin, has fallen into much the same confusion as the terminal embryo cell. While the majority of text-books give its first division as transverse, followed by longitudinal divisions, the figures and texts disagree as to the subsequent development of its tissue. In Goebel's *Outlines*, while the text describes the plate of cells, *h*, of *fig. 326*, as dividing to form calyptrogen and root cap, in the figure itself *h'* is divided instead of *h*. In Sach's *Text-book*, *h'* is so figured and the text corresponds.

It is unfortunate that such confusion exists in the embryology of Capsella, and however careful and accurate Hanstein's original work may have been, he is either ambiguous in his statements or he has been mistranslated. It seems quite probable that Capsella is very close to Alyssum in its embryonic development and the many resemblances existing between some of the stages shown in my drawings and those of Hanstein seem to lead one to the conclusion that their embryology is very similar. Perhaps a re-investigation of Capsella would show its development to be the same.

SUMMARY.

1. The hypodermal archesporial cell divides into a tapetal cell and a macrospore mother cell which gives rise to four macrospores, three potential macrospores and a vital macrospore, the lowest of the series, which develops into the embryo sac.

2. The embryo sac passes through the usual cell divisions, increasing in size and becoming much curved, until the entire nucellus is destroyed.

3. The antipodals are ephemeral, disappearing during the early stages of embryonic development.

4. The endosperm appears soon after the fertilization of the oosphere.

5. The first division of the proembryo is transverse and the basal suspensor cell never divides afterward.

6. The end cell divides into the intermediate cell which contributes both to suspensor and embryo, and a terminal embryo cell.

7. The first and second series of divisions in the terminal embryo cell are longitudinal and form a quadrant. The octant is formed by a series of transverse divisions.

8. The first three series of divisions in the basal embryo cell correspond to those of the terminal embryo cell, also giving rise to an octant.

9. The dermatogen is the first tissue which is differentiated and is cut off by tangential walls in the cells of the octants.

10. The plerome and periblem arise in the basal hemisphere of the terminal embryo cells; the cotyledons and stem tip from the terminal hemisphere.

11. The calyptrogen and root cap are formed from the basal hemisphere of the basal suspensor cell, while that part of the root tip which forms the periblem of the radicle arises from the hemisphere lying next to the terminal embryo cells.

12. The number of cells in the suspensor varies from six to fifteen. The number beyond six apparently depends upon the number of intercalary divisions, some of which may be longitudinal.

13. The endosperm lines the entire embryo sac with a single layer of cells, but is more abundant around the young embryo and forms a peculiar growth in the antipodal region.

COLUMBUS, OHIO.

EXPLANATION OF PLATES XXVI–XXVIII.

Drawings reduced to three-eighths; the magnification given with each figure refers to the original magnification before reduction.

PLATE XXVI.

FIG. 1. Nucellus and integuments; archesporial cells. ×1060.

FIG. 2. Nucellus with tapetal cell, *t*; potential macrospores, *p*; and vital macrospore, *m*. ×1060.

FIG. 3. Two-celled embryo sac; tapetal cell, *t*. ×1060.

FIGS. 4–5. Four-celled embryo sac. ×1060.

FIG. 6. Eight-celled embryo sac. ×1060.

FIG. 7. Seven-celled embryo sac. ×1060.

FIG. 8. Egg apparatus and definitive nucleus. ×580.

FIGS. 9 and 9a. Embryo sac before fertilization; antipodals, *a*. ×1060.

FIG. 10. Embryo sac after fertilization; oospore, *o*; synergids, *s*. ×1060.

FIG. 11. One-celled proembryo; pollen tube, *p t*; synergid, *s*; a peculiar endosperm nucleus, *end. nu.* ×1060.

FIG. 12. Embyo sac showing relative size of proembryo and the distribution of endosperm. ×1060.

PLATE XXVII.

FIG. 13. Three-celled proembryo; basal suspensor cell, *a*; intermediate cell, *b*; terminal embryo cell, *c*. ×1060.

FIG. 14. Same, farther advanced. ×1060.

FIG. 15. First longitudinal division of the terminal embryo cell, *c*. ×1060.

FIG. 16. Second longitudinal division of *c*. ×1060.

FIG. 17. Octant stage, two nuclei cut away in sectioning; intermediate cell, *b* much divided. ×580.

FIG. 18. Embryo with dermatogen. ×580.

FIG. 19. Same, with more cells in suspensor. ×580.

FIG. 20. Embryo showing remains of pollen tube, *p t*; basal embryo cell, *e*; the terminal embryo cell is divided into two distinct tiers, *c* and *d*. ×580.

FIG. 21. Embryo showing a series of transverse divisions in tier *d*, and two longitudinal divisions in basal embryo cell, *e*. ×580.

FIG. 22. Suspensor which seems to indicate intercalary division. ×1060.

FIG. 23. Abnormal suspensor in which intercalary division has been longitudinal instead of transverse; plerome shaded. ×1060.

FIG. 24. More advanced embryo showing longitudinal division in plerome. ×1060.

FIG. 25. Transverse division following the longitudinal; basal embryo cell divided into two tiers, *f* and *g*. ×580.

FIGS. 26 and 27. Embryos from same silicle, showing abnormal suspensor and basal embryo cell. Shaded and light areas show difference in staining where triple staining was used. ×1060.

FIG. 28. Embryo having four tiers in plerome and two in the region where the stem tip and cotyledons originate. ×580.

PLATE XXVIII.

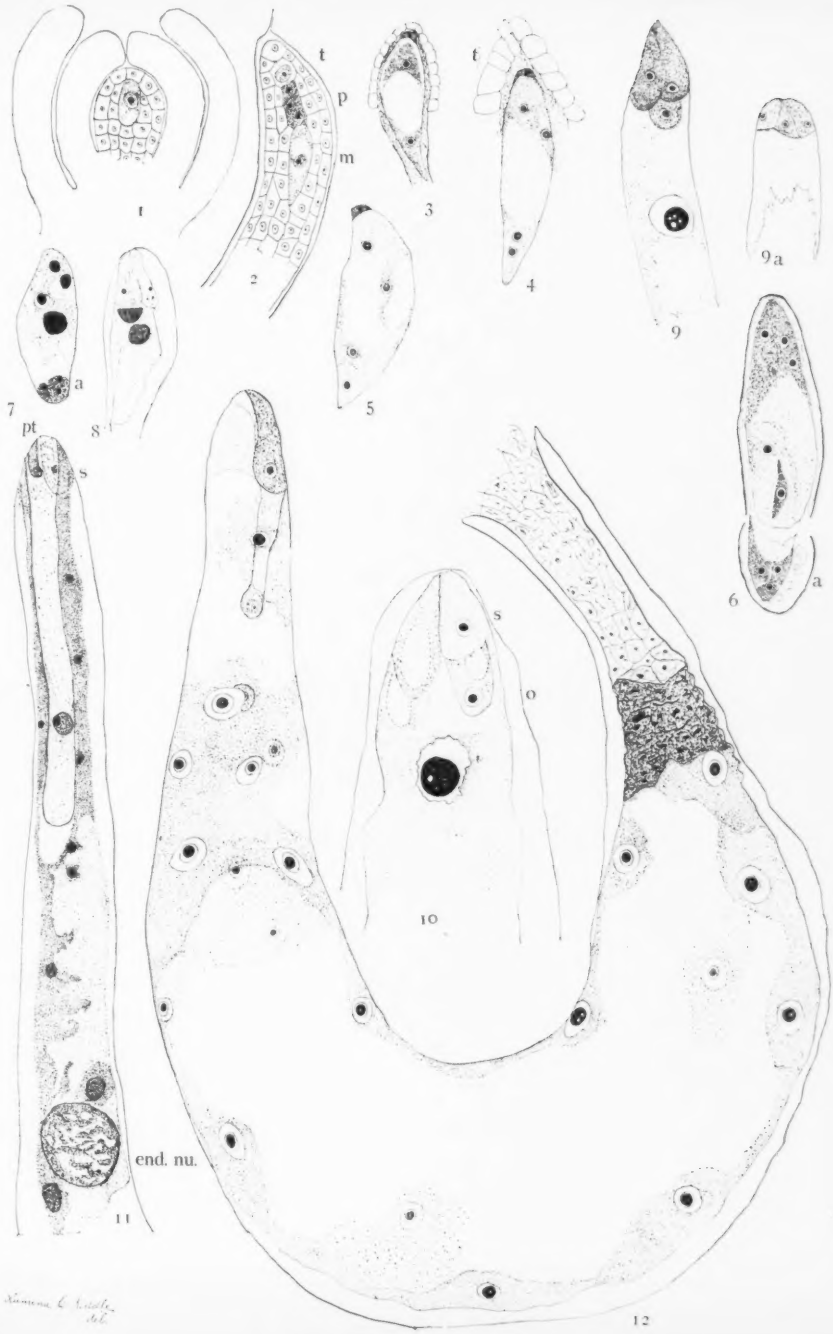
FIG. 29. Embryo with four tiers in plerome; a series of longitudinal walls appearing in the inner tier; three rows in region of cotyledons. ×1060.

FIGS. 30–32. Large embryos showing development of calyptrogen, root cap and root tip. ×580.

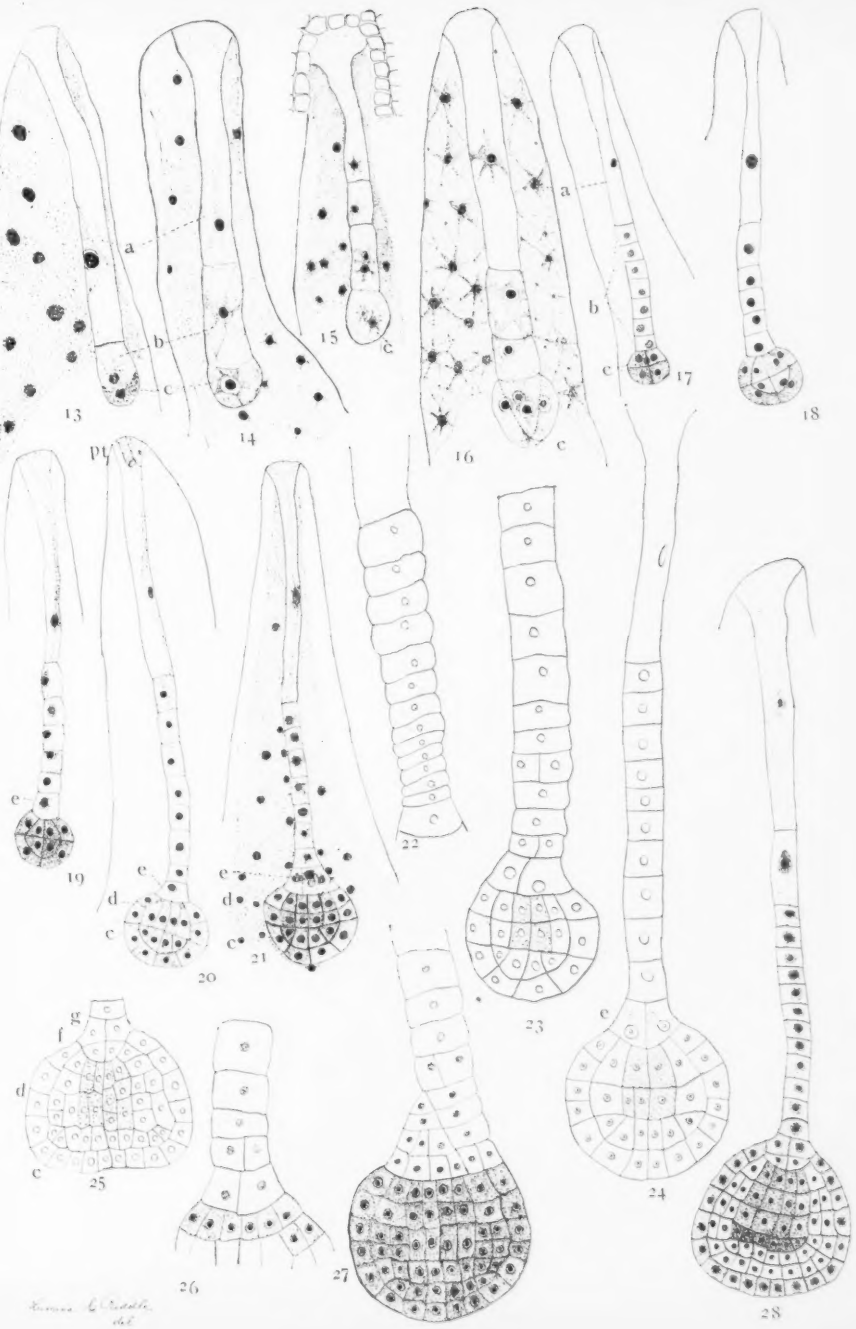
FIG. 33. Section through root tip, showing plerome, periblem, dermatogen, calyptrogen, and root cap. ×590.

FIG. 34. Nearly mature embryo showing suspensor still persisting. ×90.

FIGS. 35–39. Antipodal end of embryo sac, showing antipodals disappearing and endosperm forming thallus-like growth. *Figs. 35–38*, × 1060; *fig. 39*. × 590.



RIDDLE on ALYSSUM



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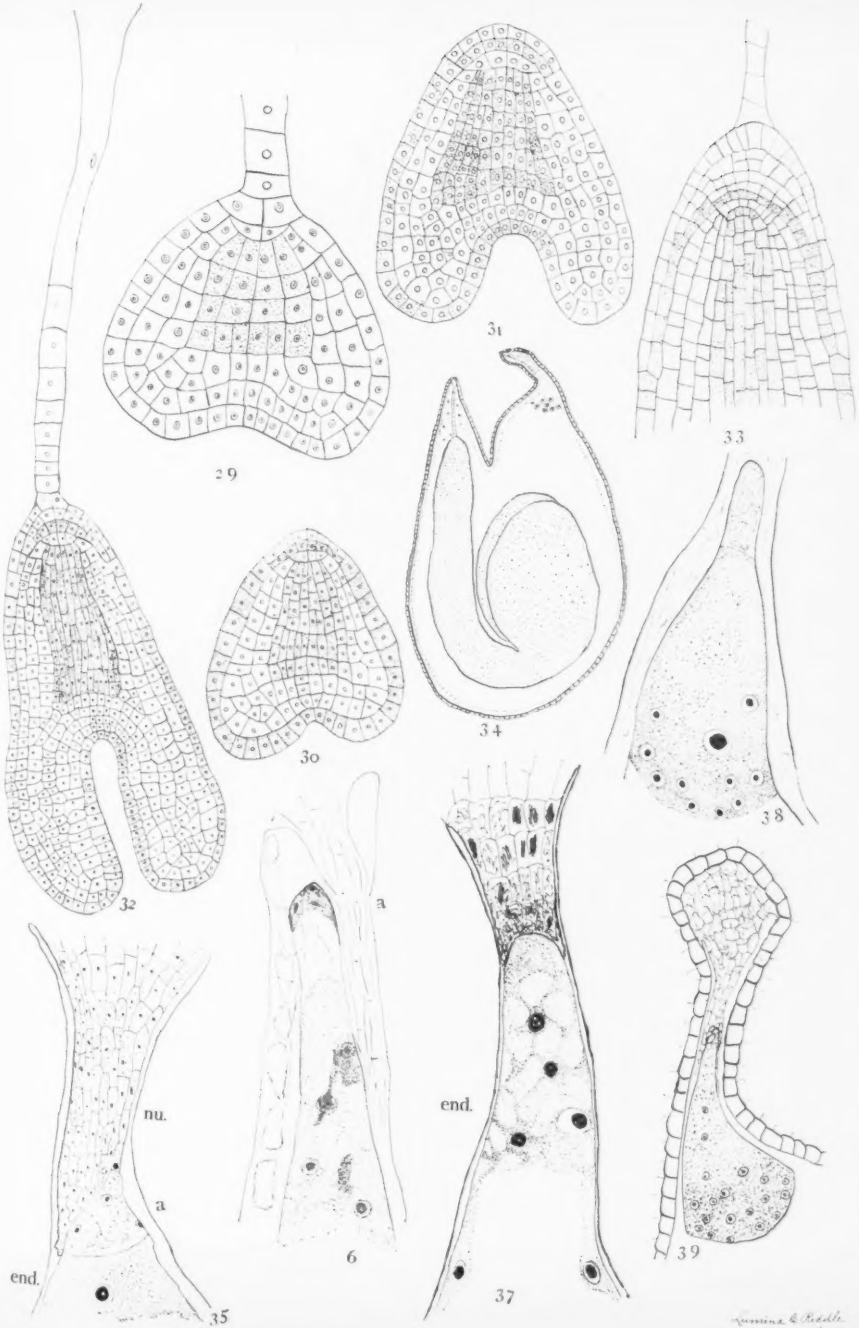


RIDDLE on ALYSSUM

FURTHER OBSERVATIONS ON THE EASTERN ACAULESCENT VIOLETS.[1]

CHARLES LOUIS POLLARD.

IN a paper published two years ago in the *Proceedings* of the Biological Society of Washington,[2] I presented a tentative revision of the purple-flowered, stemless violets found in the northeastern United States. Since that time I have been engaged in field study of the genus in New Jersey, Pennsylvania, the District of Columbia, and Virginia, a territory from which the larger proportion of early types was obtained. The excellent library of Professor E. L. Greene, of the Catholic University, has been kindly placed at my disposal, and the opportunity thus afforded of studying the unpublished colored drawings of Le Conte, illustrative of the latter's well-known monograph of the genus, has been of great value in clearing up doubtful determinations. The herbarium of the Philadelphia Academy of Sciences, containing specimens ticketed by Nuttall, Schweinitz, and Darlington, has also afforded material assistance. Many friends and correspondents, to whom I am deeply indebted, have aided me with living and dried plants.

In the paper above referred to nine species and one variety were enumerated among the purple-flowered, acaulescent class. As a result of subsequent study this number must be increased at least twofold, and Professor Greene's investigations have shown that the violets of Canada and the Great Lake region are as yet but imperfectly understood. Mr. Macoun's observations during the past season, communicated to Professor Greene, have enriched the genus by five species, all natives of Canada; and I doubt not that similar results would follow an exploration of the southern portions of British Columbia.

[1] Published by permission of the Secretary of the Smithsonian Institution.

[2] **10**: 85–92. 1896.

Before discussing certain species in detail it may be well to outline briefly the characters upon which we must depend for any thorough understanding of this genus. At the outset I wish to emphasize the importance of unremitting field work, and the absolute uselessness of herbarium material unless one is fortified by previous familiarity with the growing plant. It should not be forgotten that the value of a herbarium for purposes of systematic research lies in the advantage thereby gained of having material convenient for morphological and histological study, and not in that it provides in any sense a proper substitute for the living individuals. Habit as well as habitat, the texture of the herbage, color of the flowers, position of the cleistogenes, nervation, shape and degrees of pubescence of the leaves, nature of the surrounding vegetation; all these will be taken into consideration by the careful ionologist, and they are each best derived from outdoor investigation. Moreover we should not be content with superficial glances at occasional plants. A large number of individuals should be observed, and every feature of their environment noted; then it will be impossible for any discriminating botanist to make a comment such as I recently heard, that *Viola ovata* is "nothing but a hairy *sagittata* with ovate leaves, growing in dry ground."

In recognizing the variability of leaf-outline often presented by a single individual, there is a tendency to misapprehend or to overlook the fact that in all of the heterophyllous violets the earliest leaves are practically uniform and similar in all the species, and as they are immediately succeeded by others of a totally different type, should never be taken into account in critical diagnoses. Thus the first leaf of *V. sagittata* is cordate-reniform, obtuse and crenate, exactly like the corresponding organ of *V. palmata;* yet in the one case the characteristic foliage has lanceolate, sagittate and glabrous blades, and in the other broadly cordate, pubescent and more or less lobed blades. I am not aware that anyone has ever proposed to unite these two species on account of the similarity of their primitive leaves, and yet my attention has frequently been called to these example of early vernal foliage as an illustration of so-called "inter-

grading characters." Indeed in a recent important volume dealing with systematic botany in this country the statement is made in a footnote that "the contour of the leaf, varying upon the same individual from reniform to ovate and acute, affords no satisfactory distinction." Such a remarkable variation can scarcely be manifest to the ordinary observer unless the characterless primitive foliage is taken into consideration. With equal consistency and discrimination we might attempt to compare the various species of Ipomoea upon the basis of their remarkably uniform bilobed cotyledons. In two or three of our eastern violets leaf-contour, with respect to the mature foliage, plays an important part in differentiating the species. If it were not for the trigonous outline of the leaf of *V. emarginata*, for example, that species might by those unfamiliar with the habits of violets be confused with *V. sagittata;* but the elongated lanceolate blade of the latter cannot fail to render it distinct to any observer.

In the subjoined key I have followed the primary division of Dr. Gray and other authorities, separating *V. pedata* as a distinct class on account of the characters found in the rootstock and stigma. The remaining divisions are somewhat arbitrary, as I fully realize the futility of constructing any key in the hope that it will afford conclusive determinations of every unusual form. To the larger divisions have been given group names, partly for the sake of convenience, and partly in order to make clear the affinities of each species. A knowledge of these primary groups is often indispensable in determining a violet of doubtful relationship. The key includes all the acaulescent species east of the Mississippi now known to me, with the exception of the Canadian forms recently described by Professor Greene.[3] In the notes following the key are mentioned only those species deserving special comment.

SECTION I.

Leaves and flowering scapes directly from a short, erect caudex; plants not stoloniferous; cleistogamous apetalous flowers apparently wanting; petals beardless, blue; stigma large, not rostrate.

CLASS 1. **Pedatæ.** 1. *V. pedata*

[3] Pitt. **3**: 333 *et seq.*

SECTION II.

Leaves and scapes from a horizontal or ascending, often multicipital rootstock; plants not stoloniferous (except in CLASS 5), but bearing numerous cleistogamous apetalous flowers; petals more or less bearded, purple; stigma small, rostrate.

CLASS 2. **Heterophyllæ.** Leaves on the same individual entire or variously lobed, from cordate-ovate to reniform in general outline; scapes of the cleistogamous flowers deflexed or ascending, not erect (except in *V. Brittoniana*).

Plants always more or less pubescent — 4. *V. palmata* and *vars.*

Plants comparatively glabrous, or at most with pubescent petiole.

Western campestrine species.

Leaves divided almost to base with narrowly linear lobes — 2. *V. pedatifida*

Leaves parted scarcely to the middle with rather broad lobes — 3. *V. Bernardi*

Eastern coastal plain species.

Southern; leaves very irregularly lobed and incised.

Plant succulent — 7. *V. esculenta*

Plant not succulent — 8. *V. insignis*

Northern; leaves symmetrically lobed.

Leaves large, pedately 5–7-parted to base — 6. *V. septemloba*

Leaves with a large median lobe and pinnately arranged lateral lobes — 5. *V. Brittoniana*

CLASS 3. **Communes.** Leaves on the same individual similar or nearly so, rarely pubescent (except in *villosa*), in general outline cordate-ovate; scapes of the cleistogamous flowers either erect or deflexed.

Woodland species;[4] peduncles of the cleistogenes deflexed.

Plants small (less than 1 dm high).

Leaves reniform-orbicular, silvery-hirsute above — 15. *V. villosa*

Leaves deltoid-triangular, apparently glabrous above — 16. *V. Langloisii*

Plants large (more than 1 dm high).

Leaves broadly asariform; cleistogenes hypogaeous in fruit — 10. *V. domestica*

Leaves usually broadly cordate; cleistogenes not hypogaeous.

Keel-petal cuspidate; leaves hirsutulous — 11. *V. cuspidata*

Keel-petal not cuspidate; leaves glabrate — 9. *V. communis*

Bog-meadow species; peduncles of the cleistogenes strictly erect.

Leaves markedly cucullate — 13. *V. cucullata*

[4] By this expression is meant all dry or merely moist shaded localities as distinguished from open, sunny bog-meadows and partially shaded water courses. The position of the cleistogenes in nos. 11, 14, and 16 is uncertain.

Leaves scarcely at all cucullate.

Leaves yellowish-green, prominently veined, obtuse
14. *V. affinis*

Leaves bright green, not prominently veined, acute
12. *V. obliqua*

CLASS 4. **Sagittatæ.** Leaves all similar, ovate-sagittate or ovate-lanceolate in general outline; entire or slightly lobed; peduncles of the cleistogamous flowers strictly erect; flowers dark purple.

Plants distinctly villous-hirsute.

Spur of the corolla saccate-dilated; leaves with a deep sinus
21. *V. Carolina*

Spur of the corolla not conspicuous; leaves with a shallow sinus or none
20. *V. ovata*

Plants glabrate or only ciliate.

Leaves elongated-oval, of nearly similar diameter throughout; basal lobes conspicuous
17. *V. sagittata*

Leaves ovate-triangular, nearly equilateral, the base truncate, not often lobed; petals emarginate
18. *V. emarginata*

Leaves elongated-ovate, tapering to apex, slightly dentate at base
19. *V. dentata*

CLASS 5. **Odoratæ.** Plants stoloniferous; leaves reniform-cordate; flowers purple.

Rootstock thickened, scaly; plant introduced
22. *V. odorata*

Rootstock filiform; species native, far northern.

Leaves hirsute-pubescent, crenate
23. *V. Selkirkii*

Leaves glabrous, crenulate
24. *V. palustris*

SECTION III.

Leaves variable in outline; plants mostly stoloniferous from filiform rootstocks; spur short and saccate; stigma short, pointed; petals yellow or white, usually veined with purple; position of the cleistogenes various.

CLASS 6. **Blandæ.** Corolla white.

Leaves from ovate to orbicular; cleistogenes deflexed.

Leaves reniform, pubescent
29. *V. renifolia*

Leaves cordate-ovate, glabrate.

Petioles red-spotted; leaves pale beneath
30. *V. amoena*

Petioles not red-spotted; leaves green beneath
28. *V. blanda*

Leaves from ovate-lanceolate to narrowly linear; cleistogenes erect.

Leaves linear or linear-lanceolate.

Blade and petiole coalescent
25. *V. vittata*

Blade and petiole distinct, of nearly equal length
26. *V. lanceolata*

Leaves ovate-lanceolate, the blade decurrent
27. *V. primulaefolia*

CLASS 7. **Orbiculares.** Corolla yellow; cleistogenes deflexed
31. *V. rotundifolia*

VIOLA PEDATA L. Sp. Pl. 933. 1753.

V. digitata Pursh, Fl. Am. Sept. 1: 171. 1812.
V. pedata bicolor Bursh, *fide* Raf. in DC. Prodr. 1: 291. 1824.
V. pedata inornata Greene, Pitt. 3: 35. 1896.

This, the common bird's-foot violet, appears, as is well known, in two forms, in one of which the petals are pale blue and concolorous, in the other the uppermost petals deep velvety-purple. It is the latter form, so long known as the variety *bicolor*, which is figured by Plukenet, and on which Linnaeus based his type. Between these two extremes one finds in Maryland and Virginia every possible variation. Professor Greene considered the *pedata* of New England, which is usually the concolorous form, distinct from this variable southern plant, and bestowed on it the varietal name *inornata*. I have not been able to find characters upon which to base such a separation.

VIOLA BERNARDI Greene, Pitt. 3: 260. 1898. As synonym.

V. pedatifida var. *Bernardi* Greene, l. c.

Professor Greene applies this name to a violet very familiar to me from a specimen in my own herbarium, collected in Wisconsin by Professor S. M. Tracy some years ago, which has since passed into the possession of the National Herbarium. The plant was so remarkable that Dr. Britton originally considered it distinct, and gave it a manuscript name. In the states of Michigan, Wisconsin, and northern Illinois it seems to be the prevailing form, and apparently entirely replaces *V. palmata*. Recently specimens have come to me from Chicago collected by Dr. Moffatt, which in addition to Dr. Greene's material show the plant to be a species intermediate between the PEDATÆ and the HETEROPHYLLÆ, having the foliage and aspect of the former, together with the rootstock and variable leaf-contour of the latter. I have been unable to discover cleistogamous flowers upon the material thus far examined.

VIOLA PALMATA L. Sp. Pl. 933, 1753.

V. palmata var. α *vulgaris* Ell. Bot. S. C. & Ga. 1: 300. 1817.
V. palmata var. β *fragrans* Ell., l. c.
V. cucullata var. *palmata* A. Gray, Man. 78. 1867. [Ed. 5.]

Concerning this species there is a substantial agreement among the early authorities. Mr. Edmund G. Baker in a recent issue of the British *Journal of Botany* discusses the Linnæan type, which was based upon a poorly drawn figure of Plukenet; this might indeed stand for any of the HETEROPHYLLÆ, but Mr. Baker points out that both of Plukenet's specimens are pubescent and adds that the figure in Britton and Brown's *Flora* fairly matches the types, although these have leaves slightly less lobed. The true *palmata*, then, is a plant of rich woodlands, usually distinctly pubescent, with rather dark purple flowers, and leaves exhibiting a great diversity of lobation. I recognize in addition two well-known varieties, both of which are referable to older authorities, and abundantly represented in most herbaria.

VIOLA PALMATA DILATATA Ell., l. c.

V. triloba Schwein., Am. Journ. Sci. 5: 57. 1822.
V. congener Le Conte, Ann. N. Y. Lyc. 2: 140. 1828.

The leaves in this variety are uniformly three-lobed, though occasionally some of them will be found nearly entire, as often happens in the type. The lobes vary in shape, and are frequently dentate or incised, but the central one is constantly the largest. In the District of Columbia this is the prevailing form; indeed the range of *palmata* and its varieties is so strongly marked as almost to warrant a separation of *dilatata* and the type as two distinct species. *V. palmata* in its typical form I have not seen south of Harpers Ferry, except in the Blue Ridge mountains. In the lowlands it seems to be entirely replaced by *dilatata*. Schweinitz argues very strongly in favor of the specific identity of *V. triloba*, as he called it, and in all probability he had observed the difference in range between the two. The character of Elliott's description, and the habitat cited for his plant, leave little doubt as to its identity.

VIOLA PALMATA SORORIA (Willd).

V. sororia Willd. Enum. 263. 1809.
V. asarifolia Pursh, Fl. Am. Sept. Suppl. 732. 1814.
V. villosa var. β *cordifolia* Nutt. Gen. 148. 1818.

Dr. Britton has recognized this species in the *Illustrated Flora* and is still inclined to maintain it, but I fail to perceive in *sororia*, if the name be correctly applied, which is somewhat doubtful, anything more than an entire-leaved state of *V. palmata*. This variety seems remarkably distinct in its early vernal stage, but I have seen individuals put forth occasional lobed leaves, and it is not uncommon for specimens of *palmata* in cultivation to develop large, asariform, unlobed leaves late in the season, and in this condition they are absolutely undistinguishable from typical *sororia*. Among the early writers Pursh and Schweinitz were the only two that retained *sororia* in specific rank. Nuttall named it as a variety of *villosa*, which it somewhat suggests in habit.

Viola Brittoniana, nom. nov.

V. Atlantica Britton, Bull. Torr. Club **24**:92. 1897; not *V. Atlantica* Pomel, Nouv. Mat. Fl. Atlant. 215. 1874.

The specific designation originally assigned to this plant being clearly a homonym under all accepted rules, it is with great pleasure that I have associated Dr. Britton's name with it, the type coming from a region in which he has long lived and worked. It is essentially a maritime species, ranging practically the entire length of the Atlantic seaboard. Although I have not seen specimens from the Atlantic coast below Virginia Beach, it certainly occurs on the Gulf coast near Mobile, and probably at intermediate stations. It is a succulent, glabrous plant, exhibiting a fondness for saline soils. I have often had misgiving as to whether it might not, after all, be the true *septemloba* of Le Conte; but that is both described and figured as having flowers nearly two inches in diameter, and the cut of the leaves is also different. The plant is thriving in cultivation at the New York Botanical Garden, and when examined during the latter part of

the past summer was found to possess erect cleistogenes. This furnishes us with a connecting link between the two groups of SAGITTATÆ and HETEROPHYLLÆ. Dr. Robinson has recently kindly communicated to me specimens of a violet discovered near Boston by Mr. H. A. Purdie which I consider undoubtedly referable to this species, although there is astonishing diversity in the lobation of the leaves.

VIOLA SEPTEMLOBA Le Conte, Ann. N. Y. Lyc. **2**: 141. 1828.

I have applied this name, although with some hesitation, to a rather local violet which at once attracts attention on account of its ample, flabelliform, and deeply divided leaves, which attain in late summer an enormous development. Le Conte remarks on the great length of the peduncles and the large size of the flower, features which I have noticed in the plants obtained about Washington. He assigns it to "Carolina and Georgia, in pine barrens only," and this habitat again agrees with my observations. Finally there is a plant in the herbarium of the Philadelphia Academy of Sciences, labeled, I believe, in Darlington's handwriting "*V. septemloba*."

VIOLA ESCULENTA Ell., l. c., as synonym.

V. heterophylla Muhl. Cat. 25. 1813; not Poiret nor Bertol.
V. palmata var. δ *heterophylla* Ell., l. c.

I have not seen Elliott's type of this species, and am dependent upon a colored drawing of Le Conte's, and a specimen from Louisiana which Professor Greene has seen in the herbarium of Dr. Mohr. The leaves are wonderfully diversified in outline and lobation after the manner of the following species, but it is stated by Elliott that the whole plant is extremely succulent, and is used by the negroes as a pot-herb. In the National Herbarium is a specimen from Elmira, New York, which would seem to match these characters, but I should hesitate to call it *V. esculenta* without having seen individuals from intermediate stations. The habitat of this violet is given as swamps, and in this preference it is distinct from all other members of the HETEROPHYLLÆ

Viola insignis, n. sp.

Acaulescent, glabrous, 2–5^{dm} high: stipules linear-acuminate, slightly ciliate; leaves long-petioled, the early ones cordate-ovate, the later broadly trigonous, with truncate base and very obtuse apex, variously 3–5 lobed, the central lobe largest; margins obscurely crenate, denticulate or nearly entire; venation distinctly palmate: flowering peduncle usually bibracteate, not surpassing the foliage: flower very large (4^{cm} in diameter), deep purple, the petals oblong, and of nearly equal size; lateral petals conspicuously bearded with glistening white hairs; spur short; sepals narrowly lanceolate and acuminate: capsule and apetalous flowers not observed.

Dry pine barrens, northern Florida. Types in U. S. National Herbarium, Curtiss no. 4518a, Jacksonville; A. Fredholm no. 425, Duval county. I would also refer here Nash's specimen from Eustis, no. 203, the leaves of which exhibit a form of lobation akin to that in *Brittoniana*, a pinnate arrangement of small lateral lobes on either side of a large central one; in this case, however, the two posterior lateral lobes are decidedly runcinate, as shown in the detached leaf shown in the accompanying figure. The species is the sole representative of the HETEROPHYLLÆ in Florida, so far as I have observed; and although from the illustration it may appear to resemble *palmata* it is most conspicuously distinct from that species.

Apparently all the members of the HETEROPHYLLÆ (with the exception of *V. Brittoniana*) produce their cleistogamous apetalous flowers on horizontal, or at most ascending, peduncles. The tendency of the ripening capsule is to seek the surface of the ground where it sooner or later becomes partially buried. In the matter of pubescence the species are divided, *palmata* exhibiting nearly constant pubescence, while the remaining species are glabrous or only sparsely hairy. The term glabrous must be used in a comparative sense where violets are concerned, since there is rarely a case in which traces of pubescence or ciliation cannot be found. With respect to leaf-variation it will

also be noted that the primitive leaves in nearly every species are alike, and differ widely from the mature foliage.

VIOLA INSIGNIS, *n. sp.*

In the species of the next class, the COMMUNES, lobed leaves are rare exceptions. The position of the cleistogamous flowering peduncles is horizontal in the woodland species, and strictly erect in those growing in bogs or swamps. The physiological reasons for this are not clearly understood; but it is hoped that a series of experiments to be undertaken next season may shed light on the matter.

Viola communis, nom. nov.

V. obliqua and *V. cucullata* of recent authors; not of Hill nor of Aiton.

This, the commonest of our eastern violets, is separable from the below-mentioned segregates by the following combination of characters: Plant very stout, at flowering time low, but in late summer attaining a height of from eight to twelve inches; herbage bright dark green: leaves quite glabrous, cordate to reniform, more or less cucullate, very regularly crenate and distinctly obtuse at apex; nervation pinnate, with several additional primary nerves from base; stipules broad and foliaceous, laciniate: flowers deep purple, borne on peduncles almost invariably shorter than the petioles; cleistogamous flowers on horizontal peduncles, the oblong, scarcely angled capsules ripening on or beneath the surface of the ground.—Inhabits various situations, but prefers rich, moist soil in open places. I have emphasized these well-known characters in order that they may be borne in mind in comparison with the species discussed below, and I shall attempt to show that neither the *cucullata* of Aiton nor the *obliqua* of Hill can be regarded as identical with this plant unless we follow the lead of conservative botanists and continue to treat the species as an aggregate.

VIOLA DOMESTICA Bicknell, Britton and Brown, Illust. Fl. **3**: 519. 1898.

This peculiar violet has frequently been the subject of discussion between Dr. Britton, Mr. Bicknell and myself. I had concluded to publish it as a variety when I heard that Mr. Bicknell's specific description was already in type; and it very prob-

ably is better regarded as a species, although the strange habitat, which is invariably rich, cultivated ground in the close vicinity of dwellings, suggests that it originated as a cultivated variety. The range should have included the District of Columbia, for it is not uncommon here in congenial situations. Mr. Bicknell did not call attention to a very conspicuous peculiarity of the cleistogenes, namely, the tendency to bury themselves deep in the ground instead of remaining close to the surface. The leaves attain enormous proportions, frequently attaining a breadth of eight inches.

VIOLA CUSPIDATA Greene, Pitt. **3**: 314. 1898.

I have seen only young flowering specimens of this plant in cultivation at the Catholic University. Professor Greene considers it allied to *palmata*, but aside from the pubescence, the characters are those of the COMMUNES. It is a native of the Lake region and of Canada.

VIOLA OBLIQUA Hill, Hort. Kew. 316. *pl. 12.* 1769. Not of Aiton nor of Pursh.

In assigning Hill's name and figure to a certain slender plant of wet rills and shaded rocks, with glabrous foliage, narrowly ovate, cordate and acute leaves, I believe we can be certain both of matching the type and finding ourselves in general agreement with the botanists of the early part of this century. It is fully as likely that this little plant may have been discovered by some collector and sent to Kew as the hedgerow species which I have called *communis*, especially since the latter does not properly agree with Hill's figure.

VIOLA CUCULLATA Ait., Hort. Kew. **3**: 288. 1789.

Professor Greene was the first to separate this species from the *communis-obliqua* aggregate, and additional observations have amply justified his conclusions. Dr. Britton has included the plant in the appendix to the *Illustrated Flora*, and there seems

no doubt that it is the original *cucullata*. It is remarkable for the very pale blue flowers and light green foliage, which does not thrive in late summer like that of other members of the COMMUNES, but often collapses so that it is difficult to secure specimens showing the erect cleistogenes. The leaves are broader than long, with margins only slightly crenate or denticulate, the apex obtuse, and all or most of them cucullate. In *obliqua*, on the other hand, they are rather longer than broad, with sinuate-crenate margins and scarcely at all cucullate. Both species grow in moist soil, and both produce erect cleistogenes, very different, it will be observed, from *V. communis*. I think I have now shown the specific differences existing between the latter and its allies. There remain only two other names which could be possibly taken up for *communis;* one of these is *V. papilionacea* of Pursh, which I have seen figured by Le Conte, and which is totally different from any violet now known to us; the other is *V. affinis* Le Conte, discussed below.

VIOLA AFFINIS Le Conte, l. c. p. 138.

In an issue of *Pittonia*[5] which has just come to hand. Professor Greene makes the following statement concerning *V. affinis:* "This fine species, common enough in most woodlands of the District of Columbia and adjacent Maryland, was identified by me to my own satisfaction by Le Conte's excellent description, nearly two years since." Inasmuch as the description referred to is exceedingly brief and the characterization of the foliage as "foliis ovatis subacuminatis, crenato-dentatis" might be applied with equal propriety to many other violets, it is difficult to understand the grounds for Professor Greene's preemption of the name *affinis* for a species "common in most woodlands of the District of Columbia." It has always seemed to me that Le Conte himself places a very effectual obstacle in the way of our understanding when he observes at the close of his description "Nimis praecedenti affinis; nullos characteres distinctivos praeter pedunculi brevitatem et latiora calycis sepala invenire

[5] 3: 337.

possum." In the light of this declaration I had always considered *V. affinis* a synonym of *V. cucullata*, the "preceding species" referred to by Le Conte. Nevertheless, having since examined the latter's colored drawing of *V. affinis*, I am inclined to agree with Professor Greene that the species is a distinct one, but I would refer to it a plant which to the best of my knowledge does not grow in the District of Columbia, but is of northward distribution. It is an inhabitant of shaded wet rocks, and has pale bluish-purple flowers ("basi albidis" as Le Conte says), and yellowish-green leaves shaped more like those of *ovata* ("foliis ovatis cordatis") than like those of most violets belonging to the COMMUNES.

VIOLA VILLOSA Walt. Fl. Car. 219. 1788.

V. cucullata var. *cordata* Gray, Man. 78. 1867. [Ed. 5.]
V. palmata var. *villosa* Robinson in Gray, Syn. Fl. N. Am. 1: 196. 1895.

In spite of the undivided foliage of this plant it suggests the HETEROPHYLLÆ more than the COMMUNES. Happily there is no difference of opinion of the applicability of the name, although the latter is not well chosen as the leaves are hirsute rather than villous. The flowers show more of a reddish tinge than those of any other violet with which I am familiar.

VIOLA SAGITTATA Ait. Hort. Kew. **3**: 287. 1789.

This species was thoroughly well known and understood until it was made a general receptacle for other species of the same group. It was never characterized as "polymorphous" by either Elliott, Schweinitz or Le Conte, although in recent years it has been a stumbling block for many a student of the Violaceæ. As a matter of fact there is no violet more constant or unvarying either in foliage or habitat. It may be recognized by the very dark purple flowers, distinctly sagittate, narrowly oval, usually glabrous leaves, the petioles of which always exceed the flowering scapes. It chooses wet, springy spots along brooks as its favorite location, although it is frequently found in moist meadows.

VIOLA SAGITTATA SUBSAGITTATA (Greene).

V. subsagittata Greene, Pitt. 3:316–317. 1898

Professor Greene thus explains his description: "I here propose, for a new subspecies, what is known throughout a great extent of country west of Lake Michigan, as *V. sagittata*." He further states that the differences consist in the marked pubescence, the larger flowers, and the smaller dimensions of the plant. I infer from his characterization of it as a subspecies that Dr. Greene would agree with my disposal of it as a geographical variety.

VIOLA EMARGINATA (Nutt.) Le Conte, l. c. p. 142, excl. char.

V. sagittata var. β *emarginata* Nutt. Gen. 148. 1818.

It is unnecessary to add anything to the very elaborate description of this plant published, with figures, in Pittonia **3**: 255, especially as Dr. Britton has also admitted the species in the Appendix to the third volume of the *Illustrated Flora*. It should be observed that although Le Conte raised Nuttall's variety to specific rank, and hence must be quoted as authority for the name, the plant which he had in mind, as shown by his figure and description was the following:

VIOLA DENTATA Pursh, Fl. Am. Sept. **1**: 172. 1812.

V. Porteriana Pollard, Bull. Torr. Club **24**: 404. 1897.

Misled by Le Conte's reference of Pursh's *dentata* to *emarginata*, I redescribed this imposing violet last year, after abundant specimens had been secured on an excursion of the Torrey Club to Bushkill, Pa. While its relationship is with *V. ovata*, I do not think the two plants can readily be mistaken for each other, and there is the further fact to be noted that *dentata* is a species of high altitudinal distribution, all the material that I have examined having been collected either in the mountains of eastern Pennsylvania or the Blue ridge in Virginia.

VIOLA OVATA Nutt., l. c. p. 148.

V. primulifolia Pursh, Fl. Am. Sept. 1:173. 1812; not *V. primulaefolia* L. 1753.

V. ciliata Muhl. Cat. 26. 1813, without synonymy or description.
V. sagittata var. *β ovata* T. & G. Fl. N. Am. 1 : 138. 1838.

In the typical form, as shown by contemporaneous collections in the herbarium of the Philadelphia Academy of Sciences, the leaves are oval rather than ovate, tapering somewhat at base as well as apex.

VIOLA OVATA HICKSII Pollard, Proc. Biol. Soc. Wash. **10**:92. 1896.

V. sagittata Hicksii Pollard, Bot. Gaz. **20**: 326. 1895.

Leaves distinctly deltoid-ovate, rather truncate at base. The prevailing form in the District of Columbia.

VIOLA CAROLINA Greene, Pitt. **3**:259. 1898.

I have not yet seen material of this species aside from the type sheet in Professor Greene's collection. It is apparently quite distinct from other members of the group in the south.

VIOLA ODORATA L. Sp. Pl. 934. 1753.

V. Thompsonæ Chapm. Fl. S. States 34. 1897. [ed. 3.]

A specimen of this violet was sent to the National Herbarium by Mrs. Thompson at the same time that it was placed in Dr. Chapman's hands, and was immediately recognized as *V. odorata*, a familiar escape in the north, but evidently not hitherto reported from the southern states.

VIOLA VITTATA Greene, Pitt. **3**:258. 1898.

This replaces *lanceolata* throughout the extreme southern states. The leaves are unlike those of any other violet in that they are so short-petioled as to appear almost sessile; hence when they have attained full dimensions they bear a strong resemblance to the fronds of *Vittaria lineata* as the describer of the species has already observed.

VIOLA PRIMULÆFOLIA L. l. c.

A somewhat variable species. I have ventured to segregate as a variety the southern material as follows:

VIOLA PRIMULÆFOLIA **australis,** n. var.

Leaves much larger and thicker, decurrent on the reddish-tinged petiole; flowers larger than in the type (1–1.5^{cm} broad, odorless. Throughout the southern states. Type in the National Herbarium, A. Fredholm, no. 431, Duval county, Florida.

VIOLA AMŒNA Le Conte, l. c. p. 144.

V. blanda var. *palustriformis* A. Gray, Bot. Gaz. 11. 255. 1886.

A much larger and more robust plant than *blanda*, usually more pubescent, with reddish petioles and odorless flowers. It is frequently stoloniferous, which is rarely the case in *blanda*, and prefers moist cliffs and shaded regions rather than the wet, grassy meadows in which *blanda* abounds.

WASHINGTON, D. C.

A NEW SELF-REGISTERING TRANSPIRATION MACHINE.

EDWIN BINGHAM COPELAND.

TRANSPIRATION is so important and conspicuous a function of ordinary land plants that the number of papers dealing with it, as a whole or in part, sufficed already a decade ago to justify the compilation of "the materials for a monograph." No contributor to this literature can have failed to feel the need of some device by which he could record the plant's loss of water, with such ease and accuracy as various auxanometers, for instance, make possible for its growth. Several contrivances for this work have been described, and a few have been put to actual use by their inventors; but none has as yet been well enough adapted to the purpose to bring it into general use, or make it any standard part of laboratory equipment.

Pfeffer[1] refers for such apparatus to papers by Vesque, Eder, Krutizky, Marey, and Anderson. Eder[2] measured only the absorption of water. A tracer fastened to a cork floating in a burette from which the water is drawn makes the absorption self-registering. The apparatus used for investigation by Vesque[3] was not self-registering, but was simply a glass siphon with the shoot being tested in one end, and filled to a given point in the other arm with water, and weighed; after a time it was reweighed, showing the weight of water transpired, and filled to the original level and weighed, showing the weight absorbed. Absorption and transpiration are not necessarily equivalent, for any given time-interval. Krutizky's[4] apparatus consisted of a siphon into

[1] Pflanzenphysiologie **1** : 224. 1897. [Ed. 2.]

[2] Untersuchungen über die Ausscheidung von Wasserdampf bei den Pflanzen 106. Leipzig. 1875.

[3] L'absorption comparée directement a la transpiration. Ann. Sci. Nat. Bot., VI. **6** : 201.

[4] Beschreibung eines zur Bestimmung der von den Pflanzen aufgenommenen und verdunsteten Wassermenge dienenden Apparates. Bot. Zeit. **36** : 161.

one end of which a leaf or shoot was sealed, while the other was connected with an areometer. The water absorbed by the shoot was drawn from the areometer, which would then rise, and its rise could be recorded by a needle attached to it and traveling on a smoked cylinder. As far as I know, this apparatus has never been used at all. Pfeffer's citation of Marey is "Methode Graphique, 1st ed.," which I have not seen. In the second edition, 1885, pp. 255–258, are brief descriptions of several machines for the automatic registration of changes in weight, used in meteorology to measure rainfall, but equally adapted to use in measuring transpiration, as is illustrated by a curve obtained by Marié-Davy with one of them. Anderson's[5] plan is to collect the transpired water by means of an absorbent on a scale pan. When the balance is sufficiently disturbed, an electric circuit is closed, which drops a weight on the other pan, restores the equilibrium, and makes a record of the time.

Woods[6] has used a rain gauge to measure transpiration, the machine being set up so that the plant's loss of weight opens an electric circuit, this moves the tracing pen and also a counterweight, which closes the circuit again. A sample of the record shows the soundness of the device. Francis Darwin[7] speaks of an attempt to construct a self-registering balance by placing a spring under one pan and prolonging the knife edge as a tracer.

All of these devices except Darwin's, which was never applied to measuring transpiration, are founded on one or the other of two principles: the use of the areometer, as in the apparatus of Rédier and of Salleron, cited by Marey, and of Eder, Krutizky, and Vesque; or the imposition of counterweights at the instant demanded by the change in weight of the subject, as in the apparatus of Ragona, described by Marey, and of Anderson and Woods. They have employed both of the reliable methods of measuring the transpiration, namely, weighing the plant, and collecting and weighing the evaporated water. Eder made a

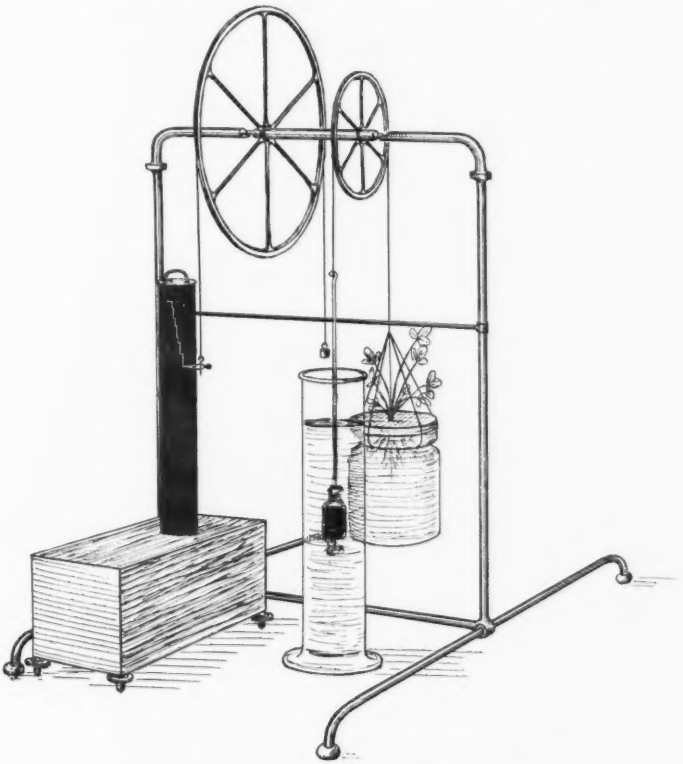
[5] Minnesota Botanical Studies 1 : 177. 1894.

[6] Recording apparatus for the study of the transpiration of plants. BOT. GAZ. 20 : 473.

[7] Annals of Bot. 7 : 461.

mistake in measuring the water absorbed, and Krutizky's apparatus is inapplicable for the same reason.

The apparatus now to be described was made for the Indiana University, from my plan, through the Cambridge Botanical



A SELF-REGISTERING TRANSPIRATION MACHINE.

Supply Company, by Professor J. C. Arthur. The cost is about $35. The frame, made of iron tubing, stands twenty-five inches high, and is fifteen inches wide. Each arm bears at the end a piece of plate glass, which must lie with its upper face exactly horizontal. Two wheels of aluminum, cut out so as to

be as light as possible and perfectly centered, have a common axis, whose ends are slender cylinders, rolling on these plate-glass supports. The wheels are six and twelve inches in diameter, and absolutely true; when not loaded they are at rest anywhere on the supports. Over one of the wheels—the smaller one, as I have used the apparatus—runs a thread or string, which carries on one end the plant whose transpiration is to be tested. The other end is fastened to an areometer, weighted until it is partly submerged. For this areometer I use a bottle partly filled with mercury, with a tight-fitting cork, into which is sealed a glass rod or tube. It is convenient to use a tube, so that the load of mercury can be adjusted without disturbing the cork. For the string I used double heavy silk thread, boiled in beeswax, and rubbed until it would not stick to the wheel. It was fastened to the upper end of the glass tube, out of contact with liquid water, and altogether was pretty well protected against hygroscopic changes in length.

Now, as the plant transpires it becomes lighter, and the areometer sinks, displacing exactly the mass of water at that end of the string which has been lost by evaporation at the other. If, for example, the area of a section of the tube be $1^{sq\ cm}$, it will sink 1^{cm} while the plant loses 1^{g} in weight. The larger wheel carries a thread, with a tracer which leaves its record in the same way as that of an auxanometer.

What are the limitations of the working of the machine? When it is used with proper care, there is practically but one, the inertia of the resting load which the wheel carries. Friction is practically eliminated. The axis turns more easily than would be feasible on ball bearings. The only remaining obstacle to perfect ease of movement is the surface tension of the water; but the capillarity is not very considerable even at its theoretical maximum, which is never reached, and if the tube is uniform and clean it will hardly vary as the tube descends. Jars and irregular drafts must of course be avoided.

It has been possible to put the apparatus to an unfortunately brief test. Both potted plants and water cultures were used;

the latter are rather more convenient since there is only the top of the containing vessel from which evaporation must be prevented. Several attempts were necessary before a large enough tube was used on the float; *i. e.*, the apparatus was at first set up so as to be too sensitive. A slender tube is appropriate when the intervals of time are short; but it sank so fast that it reached bottom within a few hours. The results introduced below were obtained by the use of a tube whose cross section was $\frac{5}{8}^{\text{sq cm}}$; one, therefore, which would sink 8^{cm} while the plant lost 5^{g}. in weight. As the areometer sank, the water it floated in rose a very little, but this is not a source of error because the water was in the same vessel when the value of a unit of movement was determined. I did not guard against evaporation from this water, as would be advisable if the clover plant instead of the apparatus were the real subject of experiment. For the same reason, the temperature and relative humidity do not concern us here. The plant was a red clover with about ten leaves, grown in soil, but transferred to water two days before the experiment began.

The data are derived from an experiment on June 15 and 16, and are given in measurements of vertical distances on the smoked cylinder, and in grams of water. Hours in light-face figures are A.M., those in bold-face figures P.M.:

Hour	Record in mm.	Weight in gm.	Hour	Record in mm.	Weight in gm.
9–10	25.6	0.800	**1–2**	2.9	0.091
10–11	20.3	0.635	**2–3**	3.7	0.116
11–12	14.6	0.456	**3–4**	3.5	0.109
12–1	22.3	0.697	**4–5**	3.9	0.122
1–2	29.5	0.922	**5–6**	4.6	0.144
2–3	4.0	0.125	**6–7**	14.2	0.444
3–4	3.8	0.119	**7–8**	22.9	6.716
4–5	4.0	0.125	**8–9**	26.6	0.831
5–6	5.9	0.184	**9–10**	31.1	0.972
6–7	4.2	0.131	**10–11**	23.0	0.719
7–8	3.9	0.122	**11–12**	9.9	0.309
8–9	3.7	0.116	**12–1**	8.7	0.272
9–10	3.0	0.094	**1–2**	11.9	0.372
10–11	2.7	0.084	**2–4**	15.2	0.473
11–12	2.3	0.072	**4–5**	6.3	0.197
12–1	3.0	0.094	**5–6**	5.5	0.172

In measuring the distances registered on the smoked cylinder I attempted accuracy to 0.1^{mm}, which is rather finer than is safe. I believe that the real limit to the accuracy of the results to be obtained with this apparatus lies in our ability to measure the trace. The weight on each side of the wheel in this test was only about 700^{gm}, less than would often occur in practical use. It has not been practicable to make a test with a greater load than 3.5^{kg}, with which, under proper conditions, it responds to a change of not more than 50^{mg} in either direction.

It is a merit of this apparatus that it will register equally well a decrease or an increase in weight, without any change in the setting up, except as the areometer will be set deep in the water if a continued increase is anticipated. It can be used to measure the changes in weight of fruits, etc.; and with some modification in details, the plan of the experiment is a good one for delicate and accurate measurements of the pressure of growing roots, the lifting power of prostrated grass stems, etc.

Finally, one comment on the table, introduced only as an illustration, a further discussion being reserved for a future time: the remarkable transpiratory activity during a few hours of both forenoons is not an error, nor does it seem to be an accident; for four different plants of red clover showed the same striking behavior.

MADISON, WIS.

BRIEFER ARTICLES.

THE SEEDS AND SEEDLINGS OF SOME AMENTIFERAE

(WITH PLATE XXIX)

APPARENTLY few observations have been recorded upon the seedlings of this group. Sir John Lubbock[1] briefly describes seedlings of Juglans and Pterocarya, and some representatives of the different genera of the Fagaceæ and Betulaceæ. There has been much confusion regarding the seeds of the Juglandaceæ. De Candolle[2] interpreted the parts of the embryo correctly, as did Kronfeld[3] and Lubbock, but most writers on systematic botany have misunderstood them. The seeds and seedlings studied represented the following genera: Juglans, Hicoria, Fagus, Castanea, and Quercus. Some of the seedlings were grown in moss in the greenhouse and were not subjected to frost action or cracking. Other seedlings of the same species were grown in the garden from seeds planted in the fall. *Juglans nigra* and *J. cinerea* were the only ones that would not grow in the greenhouse. They obviously required the frost action to break their shells.

JUGLANDACEÆ. As is well known, the fruit in this family is a nut, enclosed in a fleshy pericarp, endosperm is absent, and the embryo is straight. The pericarp ruptures into four valves in Hicoria and is normally indehiscent in Juglans. The wall of the nut is bony and splits into two valves on germinating. The embryo is large and fleshy, two large lobes which appear like cotyledons stand erect on a short hypocotyl. De Candolle[4] well describes the condition: "The cotyledons are always opposed to the valves of the nut, each of the chambers in the nut contains the halves of two different cotyledons." In Hicoria, the cotyledons are two-parted and intricately folded, and a lobe of one cotyledon unites with a lobe of the other by a peculiar

[1] LUBBOCK, SIR JOHN: A contribution to our knowledge of seedlings.

[2] CANDOLLE, C. DE: Mémoire sur la famille des Juglandées.

[3] KRONFELD, M.: Beiträge zur Kenntniss der Walnuss.

[4] DE CANDOLLE, *op. cit.*

turning over of the edges (*figs. 4–8*). The cotyledons are separated for some distance near the tops of the lobes. In Juglans the cotyledons are deeply two-parted (*fig. 1*); the cotyledon in the nut being U-shaped (*fig. 3*) and their lobes united to the summit (*fig. 2*). In Hicoria the shape of the embryo varies greatly in the different species. *Hicoria glabra* and *Hicoria microcarpa*, which in this region are not sharply separated, have the embryos much alike, but in *Hicoria glabra* the division between the cotyledons is twice as deep as in *Hicoria microcarpa*.

In germinating, the seed splits from the micropyle and the tip of the radicle and the two or four basal lobes of the cotyledons push out together. The petioles of the cotyledons lengthen and carry the plumule out of the nut. The cotyledons remain in the nut and do not decrease to any appreciable extent in size, but become very rancid in taste and are filled with a yellowish oil similar to that found in the husks of walnuts and butternuts. The valves of the nut usually remain slightly connected at the hilum but often are split entirely apart, and in one specimen of *Juglans cinerea* where the nut was on the surface of the ground, the two valves had separated and lay one on each side of the stem. The cotyledons, where exposed to the light, were green and could be easily drawn from the nut.

The root of the seedling becomes greatly thickened. In one specimen of *Hicoria glabra*, it was 6^{cm} long and 1.3^{cm} in diameter, and others were nearly as large. The outer portion becomes brown and fissured, the fissures extending to the endodermis. In older seedlings the root becomes very long; in large seedlings of *Juglans nigra* and *J. cinerea* it was over one-third the total length of the plant axis and in Hicoria about two-thirds. In one specimen of *Hicoria alba*, where the main stem had been killed and its place taken by a branch from the axil of one cotyledon, the young stem was 3^{cm} long and the root 20^{cm} long (*fig. 12*). The hypocotyl does not develop. The petioles of the cotyledons attain a length of 0.5 to 1.5^{cm}. The young stem bears four to eight scales before the first leaves appear. In *Juglans cinerea* these scales were two-ranked and in the same plane as the cotyledons, but in all the others they showed the two-fifths arrangement. As the seedlings naturally germinate under trees where the nuts would be buried under leaves, and as the internodes have not the power to lengthen much, Lubbock[5] suggests that the first leaves are

[5] LUBBOCK, SIR J., *op. cit.*

reduced to scales and only those that would be sure of reaching above the covering expand as true leaves. No stipules are produced. The young stem and leaves are glandular pubescent. In a number of seedlings of *Juglans cinerea* examined, the first two to four leaves were of five leaflets, the next two or three of seven, and the next ones of nine. A few had the first leaf above the scales of three leaflets. Often one leaflet of the uppermost pair of leaflets was obsolete. In *Juglans nigra* the first two to four leaves were of five leaflets, the next two or three of seven, the next two of nine, and where others were present they were of eleven leaflets. In Hicoria the first leaf was often entire or three-lobed and the next three-lobed or of two leaflets, but usually the first four or five leaves were of three leaflets. In the seedlings in the garden three or four leaves developed and then a terminal bud was formed. About the middle of July many of these buds opened and two or three more leaves developed, which were often of five leaflets. In the seed in Hicoria the plumule is made up of ten to twelve leaves. Probably not all of these develop in the first season. In the seedlings of Hicoria in the garden the main stem was often killed in some way near the surface of the ground, and the growth of the axis continued by a bud from the axil of the cotyledon or of one of the scales. In the seedling of *Hicoria ovata* figured (*fig. 12*) the main stem and the branch from the axil of one cotyledon had both died and the bud from the axil of the other cotyledon taken its place. Often in this way two, or even three, stems of about equal vigor arise.

FAGACEÆ. In Fagus the cotyledons are broader than long, notched at the apex and the two folded together into a triangular form completely filling the nut. This folding varies in different nuts. Basal lobes of the cotyledons surround and nearly cover the radicle. In Castanea the cotyledons have two to six basal lobes that nearly cover the radicle and the cotyledons are broadly ovate, thick, and entire. In Quercus the cotyledons are oval to orbicular, very thick, and entire, varying in size and shape in the different species. The basal lobes, two to six, completely cover the radicle.

In Fagus the shell splits in germinating along the three angles and the root pushes out, then the cotyledons expand and enlarge and split the shell more and throw it off. The hypocotyl lengthens considerably and raises the sessile cotyledons well above the ground. In Castanea the cotyledons swell where their petioles join them so as to force the two apart and split the shell. Then the basal lobes push out

and spread apart and the radicle grows out. The petioles of the cotyledons elongate and carry the plumule out. In Quercus germination takes place as in Castanea.

In the seedling of Fagus the root does not become greatly thickened as in the Juglandaceæ, but secondary thickening soon occurs. The cotyledons expand and become green but drop off soon after the first leaves expand. The stem and leaves are hairy; the first leaves are of the same form as the mature ones. In Castanea the root soon thickens and has longitudinal fissures extending down to the endodermis. The stem bears several scales, two to six, below the leaves, and the first leaves are of the same form as the mature ones and bear deciduous stipules. In Quercus the seedlings resemble those of Castanea, but there are often more scales on the stem, the uppermost of which bear stipules. The leaves in *Quercus velutina*, *Q. platanoides*, and *Q. macrocarpa* are all serrate and much alike, but the older leaves become more like the mature ones, but are not deeply lobed or cut. The stem and leaves are pubescent.

CONCLUSIONS. The cotyledons in Juglans and Hicoria correspond with the valves of the nut and are deeply two-lobed. The two divisions of the embryo resembling cotyledons are each made up of halves of the cotyledons.

The seeds of Hicoria germinate without frost action; those of Juglans only with frost action.

The tap root is very thick in young seedlings, and very long in older ones.

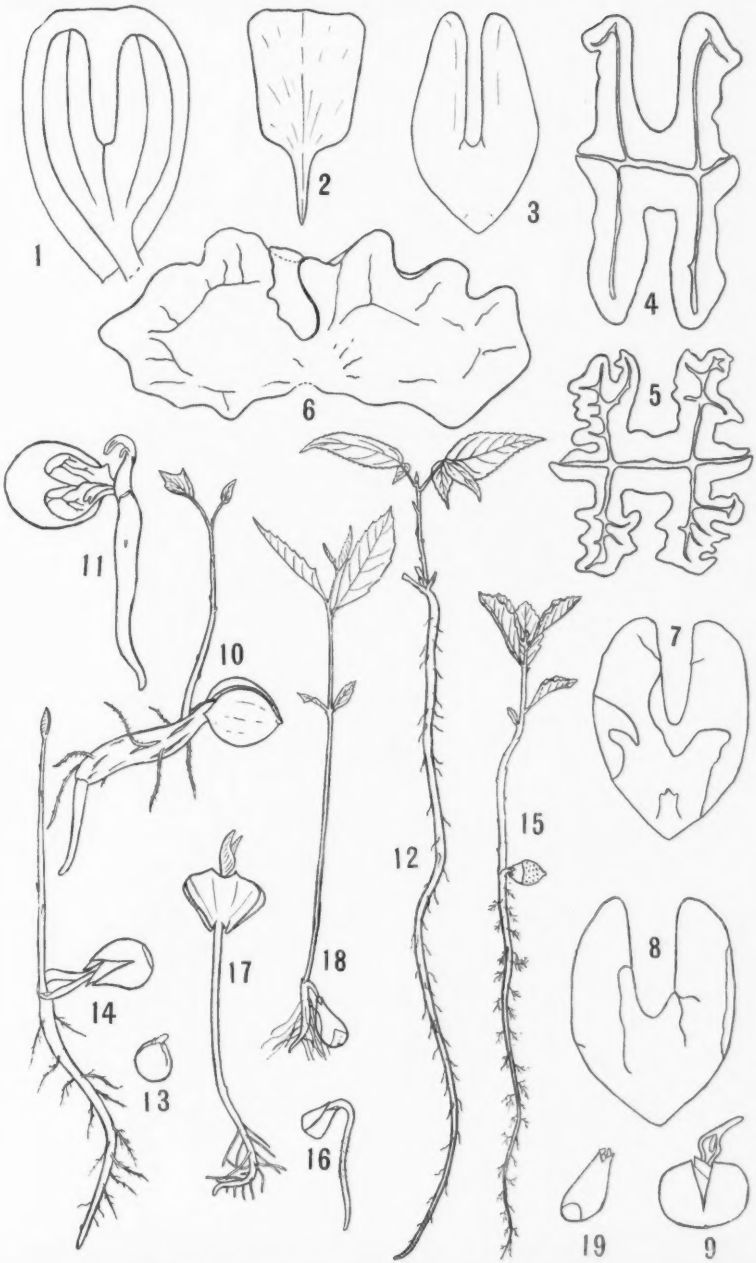
In Castanea and Quercus the shell is split in germination by a swelling of the cotyledons.

In the species of Quercus studied, the leaves of the seedlings were much alike and not deeply cut or lobed.

Fagus is the only one in which the hypocotyl lengthens, or the cotyledons become aerial.— W. W. ROWLEE and GEORGE T. HASTINGS, *Cornell University*.

EXPLANATION OF PLATE XXIX.

FIGS. 1–3. Cotyledons of *Juglans cinerea*. ×2.
FIG. 4. Cotyledons of *Hicoria laciniosa*. ×5.
FIG. 5. Cotyledons of *Hicoria minima*. ×5.
FIGS. 6–8. Cotyledons of *Hicoria glabra*. ×3.
FIGS. 9, 10. Seedlings of *Hicoria glabra*. Nat. size.



ROWLEE and HASTINGS on AMENTIFERÆ

FIG. 11. Seedling of *Juglans nigra*. Nat. size.
FIG. 12. Seedling of *Hicoria ovata*. Nat. size.
FIGS. 13, 14. Seedlings of *Quercus velutina*. Nat. size.
FIG. 15. Seedling of *Quercus platanoides*. Half nat. size.
FIGS. 16, 17. Seedlings of *Fagus Americana*. Nat. size.
FIG. 18. Seedling of *Castanea dentata*. Three-fifths nat. size.
FIG. 19. Seedling of *Castanea dentata*. Nat. size.

A GRAMINICOLOUS DOASSANSIA.

OF the species of Doassansia enumerated by Setchell in 1892[1] eight are American. Of these four find their host in Sagittaria, two in Potamogeton, one in Alisma, and one in the quite dissimilar Epilobium. In 1894 Setchell described another species on Sagittaria[2]. In 1895 Ellis and Dearness published another, also on Sagittaria,[3] while a Ranunculus was the host of a species described by the writer in the same year[4]. To the list of hosts may now be added one of the Gramineæ.

Doassansia Zizaniæ, n. sp. Subgenus DOASSANSIOPSIS as emended, BOTANICAL GAZETTE **19**: 186. 1894.

Sori globose to ellipsoidal, black, the diameter varying nearly 100 μ from the average which is about 200 μ. Cortex of one crowded row of cells which are thick walled, dark brown, nearly opaque, more or less irregularly globose, about 6 μ in diameter. The spore layer beneath the cortex is irregular in thickness but generally about three spores deep. Spores lighter brown, rather thin walled, globose to polyhedral, crowded, 6–10 μ in diameter. Central portion of the sorus composed of pseudoparenchyma, the cells of which are but little larger than the spores. Sori also occur in which the spore layer is bounded within by cells like those of the cortex, the pseudoparenchyma being absent and the central part of the sorus empty.

In the culms of *Zizania aquatica* L., Racine and Kenosha, Wisconsin, September to December. The sori are most common and abundant in the central cavity of the culm, to the walls of which they are loosely attached, but they are often abundant in the looser tissue in the

[1] Annals of Botany **6**: 21.
[2] BOT. GAZ. **19**: 185.
[3] Bulletin Torrey Bot. Club **22**: 364.
[4] BOT. GAZ. **19**: 416.

middle of the culm wall and also in the sheaths. Two or three sori sometimes coalesce to form a large sorus. No spots are produced on the culms, but those containing the fungus are usually weaker and more flaccid. Attempts have been made from time to time during a period of two years to secure the germination of the spores in the moist chamber but without success, and as the species is soon to be distributed in Ellis and Everhart's *Fungi Columbiani* this description is published without the germination characters. The analogue of *D. Zizaniæ* is *D. intermedia* Setchell. The figure accompanying the description of that species[5] shows the same general structure of the sorus. The present species differs especially in the thicker walled and more rounded cells of the cortex, thinner walled spores and smaller parenchymatous cells. —J. J. DAVIS, *Racine, Wisconsin.*

[5] BOT. GAZ. **19**: *pl. 18. fig. 1.*

OPEN LETTERS.

TWO CORRECTIONS.

THE SOURCE OF WELWITSCHIA.

READERS of the BOTANICAL GAZETTE are requested to correct an inadvertence in the August number, page 152, where it is stated that the inflorescence and dissections of Welwitschia recently given by us were made from a plant growing at Kew. The specimens were sent to me by Mr. Dinter, a German botanist and horticulturist, now settled in German S. W. Africa. The details are given in his letter published in *The Gardeners' Chronicle* **24**: 27. 1898. After making some gross dissections, I handed the material to Professor Farmer for more minute investigation.— MAXWELL T. MASTERS, *London*.

CONFUSED SPECIES OF AGROPYRON.

I am indebted to Mr. Jared G. Smith, of the Division of Agrostology of the Department of Agriculture, for calling my attention to an error in the article "Vegetation Regions of the Prairie Province" in the GAZETTE for June 1898. The grass referred to on page 385, 9th line from the bottom, should be *Agropyron spicatum*. *A. spicatum* should also be read instead of *A. pseudorepens* on page 394, 4th line from the top. *A. pseudorepens* is a grass of the meadow formation as stated on page 389; the xerophyte of the foothill region is *A. spicatum*. The same correction should be made in the Phytogeography of Nebraska in the discussion of the foothill grass formation.

This removes what seemed to be an anomaly in ecology. That the same species should be a mesophyte of the meadows and wet cañons and also a xerophyte of the table lands of the foothill region, was a puzzle. Confusion of two closely related species, which have commonly passed under the same name of *A. glaucum*, was at the root of the matter. It is very gratifying to have the systematists clear up ecological problems in this manner.— ROSCOE POUND, *Lincoln, Neb.*

CURRENT LITERATURE.

BOOK REVIEWS.

Plant Geography.

THOSE WHO are interested in plant geography are extremely anxious to see new numbers of Engler and Drude's *Vegetation der Erde* as often as possible. The first volume included the results of Willkomm's exhaustive studies in the Spanish peninsula.[1] The second volume deals with the flora of the Carpathians and is from the hands of the well-known botanist, Dr. Ferdinand Pax of Breslau.[2] The area covered by this monograph is much more limited than that which is included in Willkomm's work, comprising the mountain districts in the eastern part of Hungary. Pax began his studies in this region in 1882 and has continued them at short intervals up to the present time. Only a short time ago he published some of the results of his study, a short preliminary sketch dealing with the various elements which make up the Carpathian flora.[3]

The volume under consideration discusses the plant geography of the district in a general way only, while the author contemplates a second volume which will give a more special and detailed account of the smaller areas which make up the Carpathian region.

The introduction gives a very complete history of botanical research in the Carpathians from the sixteenth century to the present time. The historical account is subdivided into the period before Linnaeus, the Linnaean period, the period between Linnaeus and 1850, and the period from 1850 to the present. Among those who deserve especial mention are Winterl, the first professor of botany in Hungary; Kitaibel, a student of Winterl's who published a monographic work on the flora of Hungary; more recently the investigations of Borbás, Hazslinszky, Kanitz, Staub, and others, in addition to the careful work of Pax, have made this interesting region one of the best known to geographic botanists. The bibliography is unusually complete, including more than 1200 titles.

[1] See BOT. GAZ. **22**: 63. July 1896.

[2] PAX, F.— Grundzuge der Pflanzenverbreitung in den Karpathen (Engler and Drude, Die Vegetation der Erde, II). I. Band. 8vo. pp. 269, *figs.* 9, heliogravures 3, map 1. Leipzig: W. Engelmann. 1898.

[3] PAX, F.— Ueber die Gliederung der Karpathen-flora. Jahresb. Schles. Gesellsch. Vaterl. Kultur. Breslau. 1896.

The physical geography of the Carpathians is the title of the first part of the work, under which head are discussed the geographic features of the area, especially as they are related to the physiognomy of the vegetation. A short treatment of the climatic conditions closes this part of the work.

Part two, the plant formations of the Carpathians, forms the body of the work. The formations are subdivided into three series, those of the lower hills, those of the higher mountains up to the tree line, and those above the tree line. The first two series are subdivided into formations with and without trees. The treeless portions of the lower hills are especially characterized by pastures rich in the beauty of their flowers; these pastures pass lower down into meadows where greener tints predominate. Some pastures (Pusztaweide) are more xerophytic and have a lower more open vegetation. The other treeless formations are those of the rocks and hydrophytic areas. The conifers have a very subordinate display on the lower hills, the dominant forest landscape being made up of mixed deciduous woods, in which the oaks are the most characteristic trees. With the oaks are birches, elms, hornbeams and maples. Besides these forests, there are sometimes pure growths of the beech, and mixed woods along streams, made up of the ash, alder and oak. There are also marginal thickets and xerophilous juniper formations in the hill region. In the mountain region below the tree line there are mountain meadows which pass into swamps in the lower places. The open rock formations assume a more prominent place than lower down and the species present depend upon the chemical nature of the rocks, whether calcareous or not. The mountain forests are largely dominated by the beech in the lower stretches, while higher up the spruce becomes the characteristic tree and ascends to the tree line. There are also mountain woods (Buschwald) where the beech predominates but no longer as a tall tree. Above the tree line appear the subalpine formations, in which there are extensive areas covered by dwarf shrubs, especially the dwarf pines, junipers and alders, and the rhododendrons. There are characteristic mats, meadows, and rock floras in the alpine regions still higher up. At the close of the second part Pax considers the influence of man on the vegetation, especially as it finds expression in the ruderal and culture floras and in injury to the floras.

The third part is entitled "Die Vegetationslinien der Karpathen und ihre Gliederung in Bezirke." These mountains form the east or northeast limits of many European mountain plants and also the south or southeast limits of some eastern and northern plants. The reasons for this are both topographic and climatic, and there results a notable mingling of divergent floral types. Pax finds that the vast majority of the vegetation lines are closely associated with the Kaschau-Eperjeser fault line, which follows in general the trend of the mountains; in fact the close relationship between the vegetation and the geological features is constantly emphasized. After a brief treatment of the

species common to the whole Carpathian district, the author goes more in detail into the subject of endemism. A great majority of the endemic forms are isolated, well-marked types and for the most part related to Alpine or Balkan plants. Most of the endemic plants are found east of the fault line, though those of northern origin occur throughout the district. The fault line makes a natural geographic division of the region into the east and west Carpathians and the author makes still further subdivisions of a geographic nature.

In the last part is to be found a discussion of the relations between the Carpathian floras and those of neighboring districts. The closest relationship is to the flora of central Europe, a relationship which is most strikingly shown in the forest trees. The relationship to the flora of Russia and Siberia is quite evident, though of less physiognomic value. A number of other floral elements are represented in the Carpathian flora but to a much less degree. Pax next considers the distribution of the endemic plants, and finds almost complete harmony between the two. The volume closes with a presentation of the historical development of the Carpathian flora from the Tertiary to the present, the discussion of the influence of the ice age on the vegetation having special interest and also the conclusion with regard to the paths along which migrations have occurred.— HENRY C. COWLES.

Flower ecology.

AFTER INDUSTRIOUS work on the pollination and insect relations of the floras of the North Frisian islands, Hallig islands, Helgoland, Rügen, Schleswig-Holstein, Mecklenburg, Pomerania, Westphalia, Nassau, Thüringia, Switzerland and Capri, and the investigation of many special cases, the distinguished anthoecologist of Kiel has undertaken a general review of the fundamental propositions of the subject, the literature and the results of investigations made in all parts of the world.

The first volume gives a historical account of the development of flower ecology, beginning with Kölreuter and Sprengel and including references to all of the investigators who have contributed to the subject. This is followed by an account of the status of the modern flower-theory and a review of the various modes of pollination and correlated phenomena: (1) Modes of pollination and separation of forms of flowers; (2) Autogamy; (3) Geitonogamy; (4) Xenogamy; (5) Heterostyly; (6) Cleistogamy; (7) Parthenogenesis; (8) Flower classes; (9) Flower visiting insects; (10) Methods of investigation. The extent to which these topics are elaborated may be indicated by the note that 262 pages (including index) are devoted to them.[4]

[4] KNUTH, PAUL: Handbuch der Blütenbiologie unter Zugrundelegung von Hermann Müller's Werk "Die Befruchtung der Blumen durch Insekten." Vol. I. pp. 400. Vol. II, part 1. pp. 697. Leipzig: Wilhelm Engelmann. 1898.

The second part of the volume gives a bibliographical list of 2871 titles to April 1, 1898, with a special index. As a frontispiece the volume shows a portrait of Kölreuter. There are 81 figures, most of which are familiar to those who have used Müller's *Befrucktung*. *Fig. 1* is a reproduction of the title-page of Sprengel's *Entdeckte Geheimniss*.

The second volume considers the results of observations made in Europe and in the Arctic regions; of Aurivillius and Ekstam in Nova Zembla; Burkill, Scott-Elliott and Willis in Great Britain; Delpino, Comes, Nicotra and Ricca in Italy; Dalla Torre, Kerner and Schulz in the Tyrol; Heinsius in Belgium; Kirchner at Stuttgart; Loew in the Berlin Gardens; Lindman in Greenland and Scandinavia; MacLeod in Flanders and Pyrenees; Müller in Westphalia, Thüringia and Alps; Verhoeff in the West Frisian island, Norderney; Warming in Greenland and Denmark. The first part includes the families Ranunculaceæ-Compositæ. A contemplated third volume relates to investigations made in other parts of the world. The whole ground is gone over in so thorough a manner that it will not be necessary for contributors to go through so much drudgery in looking up the literature, nor will it leave much excuse for offering contributions which have no relation to the present state of what is called "our knowledge."— CHARLES ROBERTSON.

Fungicides and insecticides.

IT HAS BEEN but a few years, scarcely more than a dozen, since the range of fungicidal agents embraced little more than bluestone for steeping wheat, sulfur for dusting upon foliage, and a somewhat uncertain application of copperas. But in these last years the number of effective fungicides has become exceedingly large, and their specific application is now based upon extensive study of underlying causes and conditions. The history of insecticides and their use is very similar. One has only to consult the excellent treatise by Lodeman on the spraying of plants, published two years ago, to feel that the amount of practical knowledge the scientist now lays before the cultivator in a field where his needs are great is of astonishing proportions. The United States has borne a proud part in the development of this subject, being in fact an acknowledged leader, while France, Italy, Switzerland and Germany have, in the order named, become actively interested in vegetable pathology and prophylactic measures.

Germany, although somewhat tardy in taking up this department of investigation, now puts forth a volume on the methods of combating plant diseases by means of chemical preparations that will prove of interest to all students of the subject, as well as to the cultivators and investigators of Germany for whom it was prepared. It emanates from Halle, that city of experiment stations, and is written by Dr. M. Hollrung,[5] director of the

[5] HOLLRUNG, M.: Handbuch der chemischen Mittel gegen Pflanzenkrank-

experiment station for plant pathology of the agricultural bureau of Saxony.

The work is compiled from all available sources, American methods being extensively quoted. It devotes three pages to preparations in which the chief ingredients are of animal origin, such as fish oil, lard, soap and glue; twenty pages to those with vegetable substances, such as cotton-seed and other plant oils, resin, tar, pyrethrum, tobacco and hellebore; and the remainder of the work, 141 pages, to those with mineral ingredients. Although primarily a volume of recipes, the metric system of weights and measures being exclusively employed, yet their uses and methods of application are clearly and succinctly set forth, with an estimate of their efficiency, and references to the source of information.

The work is admirably conceived and executed, and as closely up to date as any general work is likely to be. The classification makes it handy for reference, which is further aided by a full index.—J. C. A.

Bryology of Madagascar.

SINCE THE publication in 1879 of Bescherelle's *Florule bryologique de la Réunion et autres îles austro-Africaines de l'Océan Indien*, a number of papers on the mosses of Madagascar and allied regions have been published by Müller, Bescherelle, Brotherus, Wright, Mitten, Warnstorf, Renauld, and Cardot. Collections by French officials, missionaries, and others have accumulated. M. F. Renauld has sought to bring all this scattered information together in a sumptuous volume published by order of Prince Albert of Monaco.[6]

In preparing this work he has had abundant cooperation of bryologists who have been working in this field, or those who have charge of collections from South Africa. A preface on the generic nomenclature and the value of specific characters contains nothing novel. The geology, topography, and climate of the islands are briefly described. The chapter on the distribution of the mosses is very unsatisfactory because knowledge of the region is still much too imperfect to allow adequate treatment. M. Renauld calls the bryological flora south tropical; holds that the islands constitute an independent domain, each island having its own individuality but unequally marked; and sees relations on the one hand with the flora of the Indo-Javanese archipelago through allied species, and on the other with that of the mountains of South Africa both by allied and by identical species.

The flora of the whole group is enumerated as follows: Acrocarpi 413,

heiten; Herstellung und Anwendung in Grossen. 8vo. pp. xii + 178. Berlin: Paul Parey. 1898.

[6] RENAULD, F.—Prodrome de la flore bryologique de Madagascar, des Mascareignes et des Comores, publié par ordre de S. A. S. le Prince Albert I^er^. Ouvrage couronné par l'Institut de France. Small 4to. pp. viii + 300. Monaco. 1897.

Cladocarpi 6, Pleurocarpi 306, Sphagnum 21; total 746 species — not very far short of the enumeration of North American species given by Lesquereux and James in 1884. One is surprised at this large number even when he recalls the tropical climate and the large size of Madagascar. If laid down upon the United States the island would stretch from New York to St. Louis, with an average width equal to the length of the state of Indiana.

The Prodromus contains descriptions of many new species and validates a number of *nomina nuda* by furnishing diagnoses. It is a pity that these new things were not figured. One could have cheerfully forgone the luxurious margins and hand-made deckel-edge paper, if necessary, for the sake of plates.— C. R. B.

Kerner's "Plant Life."

THE FIRST edition of Kerner's *Pflanzenleben* is well known to English and American readers through Professor F. W. Oliver's translation, entitled *The Natural History of Plants.* Kerner issued the first volume of a second edition in 1896, the second volume appearing in 1898, almost simultaneously with the announcement of the author's death.[7] Inasmuch as the second edition follows the same general methods as the first, an extended review seems unnecessary. The divisions and subdivisions are generally the same as in the older edition, although all of the subjects treated have been reconsidered and brought more into harmony with the botany of today. A very attractive addition is the incorporation of a large number of new colored plates, as well as woodcuts and text figures. Kerner's first work has been one of the most satisfactory places to find typical plant habits and landscapes, and this feature has been improved in the second edition. Among some of the new illustrations are red snow, dodder, nullipore banks, luminous moss, reed swamps, Eucalyptus, lianas, lichens, etc. In many chapters considerable additional matter is to be found.

The most noteworthy change is the omission of about 100 pages on the classification of plants. This classification always seemed out of place in a work of this kind. The book closes with an entirely new chapter on the relation between man and plants — economic botany in the broader sense. Those plants which are used in the industrial arts are first discussed, then those which are used as food by man and by domestic animals and those which are employed in medicine, and for ornamental purposes. A historical sketch of gardens follows, beginning with the ancients and ending with the botanical and other gardens of the present day. At the close of the

[7] KERNER VON MARILAUN, ANTON.— Pflanzenleben, zweite, ganzlich neubearbeitete Auflage. 8vo. Erster Band: Gestalt und Leben der Pflanze. 8vo. pp. xii + 766. *figs. 215. pl. 34* (21 colored). 1896. Zweiter Band: Die Geschichte der Pflanzen. 8vo. pp. xii + 778. *figs. 233. pl. 30* (19 colored). *map 1.* 1898. Leipzig and Vienna: Bibliographisches Institut.

topic, plants as motives in art is discussed, and such unusual botanical subjects are introduced as plants in tapestries, sculpture, painting and poetry. This last chapter is not without its value, even for botanists, especially nowadays when people are laying so much stress on the interrelationships of all subjects.—HENRY C. COWLES.

MINOR NOTICES.

AN EXCELLENT SERVICE has been rendered the collector of fleshy fungi by Mr. C. G. Lloyd[8] in the publication of a twenty-two page pamphlet on the American Volvæ. There are included 38 species of Amanita, 12 of Volvaria and one of Chitonia. The necessity for much field study and close, critical work is evident from the author's statement that in the genus Amanita there are in this country five common species, nine occasionally found and definitely known, and twenty-four that are either doubtful identifications of European species or only recorded by the discoverer, many being described from dried specimens sent to Europe for that purpose.

The author gives concise diagnostic characters for each species, with many helpful notes, and in another place gives the full description for all species not found in Stevenson's *British Fungi*. The author evidently had in mind the encouragement of inexperienced collectors, and such will find that many of their difficulties have been anticipated; but the omission of the authority for the Latin name seems an unnecessary and inconvenient concession.

One is surprised to learn that the author does not approve of the application of the Rochester rules to cryptogams, and thinks that "it would result in an endless confusion in regard to nomenclature, and retard the study fifty years." In a work intended for assistance in field study, where the most familiar names serve best, it is doubtless only necessary to follow the most prominent authorities; but critical monographic study requires the application of the Rochester or similar rules, if reasonable stability is ever to be attained.—J. C. A.

A LIST of the spermatophytes and pteridophytes of the Upper Susquehanna region has been published by Mr. Willard N. Clute.[9] This volume "is part of a general plan for an extended study of the flora about the headwaters of the Susquehanna river." It seems that this is the first compilation of the flora of the region, although a number of well-known botanists have been interested in it at various times. The author promises to record subsequent observations in annual supplements, recognizing the fact that the list

[8] LLOYD, C. G.—A compilation of the Volvæ of the United States. 8vo. pp. 22. Cincinnati, 1898. 9 ill. from photographs.

[9] CLUTE, WILLARD NELSON: Flora of the Upper Susquehanna and its tributaries. pp. xix + 142 + x. Binghamton, N. Y.: Willard N. Clute & Co. 1898.

is far from complete. An excellent introduction presents the characteristics of the region, in the way of general topography, geology, rivers and streams, lakes and ponds, bogs and swamps, mountains and ravines, altitudes, temperature and rainfall, and general characteristics of the flora. The present volume enumerates 1105 species, the nomenclature of the "Check list" and the sequence of Gray's "Manual" being used. Common names of the region, notes useful to collectors, and a certain amount of synonomy are given. The region includes several counties in southern New York and northern Pennsylvania, and the taking up of a natural area rather than an artificial one cannot be too strongly commended. The book is well printed, and is admirably adapted to its purpose.—J. M. C.

MR. AVEN NELSON has just published[10] an interesting report on the vegetation of the "Red Desert" region of Wyoming. The area referred to extends "from the Platte bluffs on the east to the Green river bluffs on the west, from the northern limit of Sweetwater county to the hills and mountains separating Colorado and Wyoming." This large area is distinctly and strongly halophytic, and although its investigation had primarily in view the economic problem, the results are of interest to ecologists. During the summer the area is practically uninhabitable, but it has proved to afford excellent winter pasturage. The amount of this winter forage is very large, and is of six kinds: "the salt-sages" (various species of Atriplex), "the sage-brushes" (artemisias), "wheat grasses" (species of Agropyron) "Indian millet" (*Eriocoma cuspidata*), "giant rye-grass" (*Elymus condensatus*), and "desert juniper" (*J. Knightii*). The much more abundant vegetation of the hill country, or summer range, is also fully described.—J. M. C.

THE FIRST PARTS of Ascherson and Græbner's flora of the North German Lowlands[11] have appeared. The work was begun as the flora of the Brandenburg province alone, but the urgent need of a new presentation of the entire flora of the North German plains becoming apparent the authors have undertaken the longer work, which is to be published in periodical fashion. Beginning with the pteridophytes, the three parts already received include the pteridophytes, gymnosperms, monocotyls, and almost all of the Archichlamydeæ. A field handbook for popular use is evidently the aim, and to secure it there has been generous cooperation by the taxonomists of the region. The work is sparsely illustrated, and the fact that very few citations are made, and that the names of authors of species are omitted, is

[10] The Red Desert of Wyoming and its forage resources. U. S. Department of Agriculture, Division of Agrostology, Bulletin 13, Grass and forage plant investigations, 1898.

[11] ASCHERSON, P. and GRÆBNER, P.: Flora des Nordostdeutschen Flachlandes (ausser Ostpreussen). Liefg. 1, 2, 3. Small 8vo., pp. 480. Berlin: Gebrüder Borntraeger.

evidence that nothing is intended beyond a current field manual for work of the most general character.—JOHN GAYLORD COULTER.

DR. CARL HOLTERMANN[12] has just published, with the assistance of the Royal Prussian Academy of Science in Berlin, an elaborate account of his mycological studies in Java and Ceylon. The morphology and in many cases life-histories of some forty forms, chiefly Basidiomycetes, are described and illustrated with a dozen fine plates. Two new genera, *Oscarbrefeldia* and *Conidiascus*, and one new species, *Ascoidea saprolegnioides*, are added to the Hemiasci. The author is not willing to follow strictly Brefeld's views in respect to the derivation of the conidium from the sporangium. His studies upon the tropical forms indicate that the two structures may be phylogenetically quite independent of one another. He believes that each has its own *Anlage*, and that the direct influence of external conditions determines the development of one or the other or both upon the same mycelium.—BRADLEY MOORE DAVIS.

PARTS 175 and 176 of Engler and Prantl's *Die natürlichen Pflanzenfamilien* contain the completion of the Umbelliferæ by Drude, and the Cornaceæ by Harms. This completes the Archichlamydeæ, a cause for congratulation among taxonomists. The parts of this great work have been noticed briefly from time to time, as they appeared, and the general purpose and its execution warmly commended. It is certainly an epochal work, and supplies a much needed compact and illustrated presentation of known genera. The breadth of the plan has not been approached by any other "Genera Plantarum." The necessity of bringing together the work of so many collaborators has made the editorial work onerous, and of course there is great unevenness of presentation. It is impossible to criticise such a work in general. The students of different groups must pass judgment upon the work in their particular fields.—J. M. C.

NOTES FOR STUDENTS.

BY GROWING plants of Indian corn from sterilized seeds in sterile nutrient fluid, to which he had added glucose, Laurent has determined that their roots are capable of absorbing organic matter in this form.[13]—C. R. B.

MR. DAVID WHITE[14] has described and figured a new lepidodendroid genus, *Omphalophloios*, from the Lower Coal Measures of Missouri, founded upon the problematic *Lepidodendron cyclostigma* of Lesquereux.—J. M. C.

[12] HOLTERMANN, CARL: Mykologische Untersuchungen aus den Tropen. 4to. pp. viii + 122. *pl. 12.* Berlin: Gebrüder Borntraeger. 1898. *M.* 25.

[13] Comptes Rendus —: 887. 1897.

[14] Bull. Geol. Soc. Amer. **9**: 329–342. *pls. 20–23.* 1898.

DR. J. WIESNER has published [15] a short paper on *Heliotropism produced by diffuse daylight.* In this paper he lays emphasis upon the fact that although the plant parts possess often an enormous capacity for heliotropic reaction, they always react to the strongest light, although illuminated by diffuse light and, therefore, impinged upon by rays from all sides. It thus comes about that the heliotropic organ places itself so as to divide symmetrically the area from which the light comes. The immediate cause of this is to be found in the fact that the direction is determined by those impulses which are not counteracted by exactly equivalent impulses.—C. R. B.

A PAPER by Hermann Barth has been running for some weeks in the Botanisches Centralblatt entitled *Studies upon the micro-chemical recognition of alkaloids in commercial drugs.* Barth finds the alkaloids in all parts of the drugs; as for example, in the pericarp of *Conium maculatum;* in the seed coats in *Peganum Harmala* and *Colchicum autumnale;* in endosperm of *Areca Catechu;* in both endosperm and embryo of *Aconitum Napellus,* and in the embryo alone of *Physostigma venenosum.* He concludes from the occurrence of the alkaloids that it is to be expected that their functions must be very various. When they occur in the periphery of the plant organs as excretions it is reasonable to suppose that they are then protective substances against the eating of such parts by animals. Those occurring in the endosperm and embryo serve, according to Heckel, as reserve foods. In most cases, however, it appears to be beyond doubt that the alkaloids are to be considered excretions, as has been commonly believed. Some useful reactions for the recognition of alkaloids are described.—C. R. B.

DR. A. NESTLER has presented to the Imperial Academy of Sciences in Vienna a memoir on "The traumatropic movement of the nucleus and protoplasm." A summary of the results as given in the *Botanisches Centralblatt* **76**: 43. 1898 is as follows: The different orientation of the nucleus and protoplasm produced by wounding is a very common and probably general phenomenon among plants. It has been observed in monocotyledons, dicotyledons, and algæ, and occurs in like fashion in leaves, stems, and roots. The orientation exhibits itself in a few hours after wounding by the movement of the nucleus and protoplasm close to that wall which is nearest the surface of the wound. The maximum stimulation was observed in most cases after two or three days. The return of the nucleus and protoplasm to their normal position is less definite. In some cases it was observed after five or six days, in other cases they appeared to remain fixed even in the intact cells immediately bounding the wound. This transposition, which according to Tangl may be designated as traumatropic, cannot be explained upon mechanical grounds, but seems to be a peculiar stimulation movement, not more exactly definable, which is connected with the living protoplasts. The trans-

[15] Berichte d. deuts. botan. Gesells. **16**: 158–163. 1898.

mission of the stimulus is observed with diminishing strength to the distance of 0.5 to 0.7[mm] from the wound. The movement takes place in similar manner in the air and in the water. It is influenced by light and perhaps also by temperature; no influence of gravity could be determined. In the guard cells of the stoma the transposition was never observed. In some cases the effect of the stimulation caused the nuclei to increase considerably in size.—C. R. B.

ITEMS OF TAXONOMIC interest are as follows: Miss Alice Eastwood has published (*Proc. Calif. Acad. Sci.* III. (Botany) **1**: 89–146. 1898) a second fascicle of her "Studies in the herbarium and the field." A study of a collection of eighty or more species of plants from San Nicolas island results in the description of nine new species and three varieties, the new species belonging to Abronia, Astragalus, Hosackia, Peucedanum, Amsinckia, Lycium, Plantago, and Malacothrix. Three new species of Cnicus from southern Colorado and Utah are described. Two new species of Synthyris from the alpine region of southwestern Colorado are added to the solitary alpine species heretofore recognized as occurring in the mountains of Colorado. Two new species of Eriodictyon are recognized as having been included heretofore under *E. tomentosum*. New species of Pacific coast plants are described under Campanula, Romneya, Sedum, Cercocarpus, and Calochortus.—In the *Journal of Botany* (**36**: 361–378. 1898) S. Schönland and E. G. Baker describe twenty-six new species of Crassula from South Africa, and R. Schlechter publishes a ninth decade of new plants from the same region. —In the current number of the *Bulletin of the Torrey Botanical Club* (**25**: 521–541. 1898) Dr. L. M. Underwood begins a series of papers upon American ferns, the initial number dealing with the ternate species of Botrychium, fifteen of which are recognized, and two described as new, one (*B. Coulteri*) from the Yellowstone National Park, the other (*B. occidentale*) from British Columbia.—J. M. C.

A CAREFUL investigation of the phenomena of fertilization in Onoclea[16] by Mr. W. R. Shaw has brought some interesting facts to light. All previous accounts of fertilization in plants agree in making it consist of the fusion of two germ-nuclei in the resting condition; and similar descriptions are given by zoologists of fertilization in animals. In Onoclea, however, the sperm-nucleus does not pass into a resting condition before uniting with the egg-nucleus, but enters the latter without visible change either of form or structure. Within the egg-nucleus it slowly enlarges and becomes granular before the final building of the nuclear substances. Mr. Shaw was not able to determine with certainty the fate of the cilia and band of cytoplasm, which, together with the nucleus, make up the spermatozoid; though from certain appearances he conjectures they are left outside the egg-nucleus. This con-

[16] Annals of Botany **12**: 261–285. 1898.

jecture he has confirmed more recently in the case of Marsilia[17] in which the behavior of the sperm-nucleus is as in Onoclea, and the cilia and cytoplasmic band are unmistakably thrown off in the cytoplasm of the egg.

Another result of Mr. Shaw's investigation is well worthy of note. Contrary to what has been seen in many cases and assumed in others, there was no evidence that a membrane is immediately formed about the oosphere after the entrance of the spermatozoid. It is suggested that in Onoclea the exclusion of other spermatozoids is accomplished, not by a membrane but by plasmolysis of the oosphere.

It is highly desirable that further observations should be made on the process of fertilization in zoidogamic plants.—WILSON R. SMITH.

A NEW SPECIES of the genus *Pleodorina* Shaw has been described and figured by Kofoid in the *Bulletin* of the Illinois State Laboratory **5**: 273. 1898, and named *Pleodorina Illinoisensis*.[18] The account of the structure and habits of the species is very full and interesting. *P. Illinoisensis* is distinguished chiefly from Shaw's *P. Californica* because the vegetative cells are always four in number at the anterior end of the cœnobium instead of constituting about one-half of the cell colony. The number of cells in the cœnobium is also smaller, usually 32 instead of 64 or 128, and the reproductive cells (gonidia) are two or three times the diameter of the vegetative cells instead of being only slightly larger or twice as large as in the Californian species.

Pleodorina Illinoisensis is found in the back waters that cover submerged lands along the Illinois river. Quantitatively it does not form an important part of the plankton, and is not as abundant as Eudorina. Dr. Kofoid realizes that in the incompleteness of our knowledge of the life history of Pleodorina we cannot be sure that it is not a form of *Eudorina elegans*. There is extensive variation in both species, and such similarity of form and measurements that the younger stages of the two are indistinguishable. The presence of four vegetative cells at one pole of the cœnobium is the characteristic mark of *Pleodorina Illinoisensis*, the remaining 28 cells becoming reproductive. In *Eudorina* the antherozoids are formed in a similar group of four cells at one end of the cell colony, and the remaining 28 cells become oospheres. If *Eudorina* should have a parthenogenetic phase among its polymorphic conditions we should expect those 28 cells to be reproductive (gonidia), and the group of four at the anterior pole might remain vegetative. Such a form, if it existed, would be identical with *Pleodorina Illinoisensis*.—BRADLEY MOORE DAVIS.

THE MOST IMPORTANT series of exsiccati for American mycological students so far issued has come to a close with the thirty-sixth volume of

[17] Berichte d. deuts. bot. Gesells. **16**: 177–184. 1898.

[18] The form of the specific name is barbarous!—EDS.

Ellis and Everhart's *North American Fungi*,[19] which appeared a short time ago. For twenty years the work has been issued with an average regularity and a uniformity in make up and quality rarely attained.

The immediate cause of the discontinuance of the work is the sad illness of one whose name never appears in connection with its publication, but whose untiring zeal and labor have contributed largely to its success. The volumes for the whole series (except the first installment of sixty copies) have been made by Mrs. Ellis, the packets folded and the specimens put in place by her; and we may well believe that without her assistance and encouragement this splendid contribution to American mycology would never have been realized.

The last issue, like each of the preceding ones, contains 100 specimens of dried fungi belonging to various groups, placed loosely in folded packets and provided with printed labels. These are attached to the leaves of a volume containing title page and table of contents. The labels occasionally bear brief critical notes, and still more seldom diagnostic characters. The naming of the specimens has been done with care, and if errors occur, they are few and unavoidable.

The *Fungi Columbiani*, by the same authors, of which thirteen centuries have been issued and which have been, heretofore, a sort of duplicate of the N. Am. Fungi, will hereafter contain species that have not yet appeared in that work, and will thus in a measure be a continuation of it. The packets in this work are not fastened into volumes.—J. C. A.

S. HIRASÉ'S second paper on *Gingko*[20] adds an important contribution to the subject of spermatozoids in gymnosperms. The development of the pollen grain, pollen tube and antherozoid are treated in detail. Three cells are cut off in succession from the main body of the pollen grain. The first of these is soon resorbed; the second persists but does not seem to take any active part in the processes which follow; the third divides into a "stalk cell" and a "body cell." As the body cell increases in size two attractive spheres appear at the poles of its nucleus and somewhat later two larger spherical bodies resembling nucleoli are found between the attractive spheres and the nucleus. These bodies which are surrounded by a dense mass of granules may possibly aid nutrition but further investigation is necessary before anything definite can be said of their physiological or morphological value. The body cell divides parallel to the long axis of the pollen tube, giving rise to two cells in which the antherozoids are organized. A beak put out by the nucleus becomes joined to the centrosome which then makes three spiral

[19] ELLIS, J. B. and EVERHART, B. M.—North American Fungi. 2d Ser. Cent. 36. Pub. by the editors, Newfield, N. J. 1898. $7.00.

[20] Études sur la fécondation et l'embryogénie du Gingko biloba. Jour. of the Tokyo Coll. of Science **12**: 102–149. 1898.

turns in the cytoplasm, in this process becoming drawn out into a spiral band along the edges of which cilia are developed. The antherozoids escape from the mother cell and swim freely in the liquid contained in the pollen chamber. According to Webber the antherozoids in Zamia are themselves ciliated mother cells and the pollen chamber contains air only.

Antherozoids in gymnosperms have now been described by Hirasé[21] in *Gingko biloba*, by Ikeno[22] in *Cycas revoluta* and by Webber[23] in *Zamia integrifolia*. All three find a pair of spherical bodies in the cell which is to give rise to the two antherozoids. Hirasé and Ikeno agree in calling these bodies centrosomes but Webber not believing that they are centrosomes calls them centrosome-like bodies, and later proposes the term blepharoplast. Bodies probably homologous with these centrosomes or blepharoplasts have recently been described by Belajeff and Shaw in several pteridophytes. While Gingko, Cycas and Zamia resemble each other in the general development of their pollen grain structures they present considerable variation in details, especially in the history of the body cell and the formation of the antherozoid.

These investigations have added so much to the evidence accumulating from other sources, that Engler has removed Gingko from the conifers and put it by itself in the Gingkoales, a group coordinate with cycads, conifers and gnetums.—CHAS. J. CHAMBERLAIN.

NUCLEAR DIVISION IN SPIROGYRA has been studied for a long time and the most contradictory results have been obtained, especially in regard to the chemical nature of the nucleolus and its rôle in karyokinesis. Some claim that the nucleolus is fully analogous with that of the higher plants, while others think it very different both in chemical composition and its rôle in karyokinesis. Some believe that the nuclear plate is formed exclusively at the expense of the chromatic network of the nucleus, others that it comes from the nucleolus and still others that it is formed partly from the nuclear network and partly from the nucleolus. The origin of achromatic parts is also in dispute, some claiming a cytoplasmic origin, others a nuclear origin and still others a mixed origin partly cytoplasmic and partly nuclear.

L. Mitzkewitsch[24] has recently presented a thorough discussion of previous literature and added a most important contribution to the subject. The most modern killing and fixing agents were employed. After washing in water, alcohol was added to the water drop by drop at intervals of a minute or more until the material was dehydrated. The transfer from alcohol to xylol and from xylol to paraffin was equally gradual.

The investigations deal almost exclusively with the nucleolus and the

[21] *Loc. cit.* and Bot. Cent. **69**: 33–35. 1897.

[22] Flora **85**: 1. 1898 and Bot. Centralbl.

[23] BOT. GAZ. **23**: 451–459 and **24**: 16–22, 225–235. 1897.

[24] Ueber die Kerntheilung bei Spirogyra. Flora **85**: 81–124. 1898.

achromatic parts of the mitotic figure. *Spirogyra subæqua* and *S. jugalis* were the principal forms studied. The sequence in *S. subæqua* is as follows: The resting nucleus has a large nucleolus surrounded by a very evident nucleolar membrane and the threads of the nuclear network are very faint. As division begins the nucleus elongates, the nucleolus loses its membrane and puts out processes which extend to the periphery of the nucleus. At this stage striations are distinctly visible in the plasma heaps at the poles of the nucleus. The nucleolar processes are now withdrawn and the nucleolus shows a differentiation into intensely staining granules and a less deeply staining ground substance. Achromatic threads now appear inside the nucleus and represent a continuation of the achromatic threads outside. The granules continue to stain more deeply and the nuclear membrane disappears, beginning at the poles of the nucleus. The granules, or chromosomes, become arranged in a single layer in the nuclear plate, while the less deeply staining substance takes the form of bows with sides resting on the chromosomes and the apices, to which the achromatic threads are attached, turned toward the poles. The chromosomes split and as the halves of the nuclear plate separate, granular threads connect them for a time.

After the formation of a new nuclear membrane the material of the nuclear plate still shows the intensely staining chromosomes imbedded in a less deeply staining mass from which processes reach to the nuclear membrane. The processes are gradually withdrawn, the chromosomes gradually become indistinguishable from the rest of the mass, the nucleolar membrane appears and the nucleolus assumes the ordinary aspect of the resting condition.

The other species studied differed only in unessential details.—CHAS. J. CHAMBERLAIN.

A MONOGRAPH of the Caulerpaceæ[25] has recently appeared from the *Annales* of the Botanical Garden of Buitenzorg. Madame Weber-Van Bosse presents a complete taxonomic account of these interesting plants, based upon a personal and very extensive examination of the various scattered herbaria. There is perhaps no group of algæ more difficult to handle than the caulerpas, and the skill with which the author has reduced the immense number of described forms and varieties to sixty-four species is admirable. The specific descriptions seem excellent and fifteen fine lithographic plates greatly assist the reader. One must regret, however, the absence of an index to species and synomyms, for an index, although a clerical detail, is indispensable to the complete usefulness of such a work.

It is exceedingly interesting that this genus Caulerpa, immense in the number and diversity of its varieties, and cosmopolitan in its distribution through the warmer waters of the globe, should apparently reproduce itself

[25] WEBER-VAN BOSSE: Monographie der Caulerpes. Ann. d. Jar. Bot. d. Buitenzorg **15**: 243–401. 1898.

entirely vegetatively. No zoospores have ever been seen, the supposed observations of Montagne and Gardiner apparently having been erroneous.—BRADLEY M. DAVIS.

AT THE MEETING of the Academy of Science of St. Louis on the evening of October 17, 1897, Mr. C. H. Thompson spoke of some interesting stylar movements of certain Marantaceæ connected with their pollination. In the course of his remarks Mr. Thompson said:

"Generally speaking, the flower of Marantaceæ is a more or less evident tube, with the calyx and corolla inconspicuous and the stamens changed into irregular petaloid staminodia, except a single fertile one. My studies of the order have been confined to three genera, Maranta, Calathea, and Thalia, and refer to about eight or ten species. In all of the species, one of the staminodia is developed into a keel-like structure, not unlike the keel of a papilionaceous leguminous flower. At maturity of the flower, this keel holds within its fold the style. On one margin of the keel, about midway between the apex and the base of the staminodium, is developed a tentacle-like body which is extremely irritable. This tentacle, in the open flower, guards the passage to the nectary. If the tentacle is irritated, the impulse is conveyed to the sheathing basal portion of the keel, which holds the style, opening the sheath and allowing the style to escape its embrace. This movement of the style is probably due to the unequal turgescence in the cells between those of the upper side and those of the lower side of the style, the greater turgescence existing in the latter. This, when the style is liberated, causes it to curve upward with considerable force. In Maranta the style forms a semicircle, coming to rest with the stigma firmly pressed against the upper staminodium. In Calathea and Thalia it makes a complete spiral revolution, bringing the stigma, in the former, into firm contact with the style, and in the latter placing it securely in a pocket formed by a fold of the inner wall of the upper staminodium. In each instance, the contact is so secure that the stigma can be reached only by destroying the flower. The sensitive tissues seem to be located in the outer cell structure of the sheathing base of the keel. An irritation from an outside agency directed against the tentacle is conveyed by that organ to the sensitive tissue, causing the sheath to open, and liberating the style, which it has been holding under great tension.

"This complicated differentiation of the flower is undoubtedly an adaptation to insure cross-pollination. To understand this better, a detailed description of the essential organs is desirable. In the flower bud the stamen lies parallel with the pistil, with its one-celled anther placed just back of the stigma and on the style. Immediately preceding the opening of the flower, the anther dehisces, shedding its pollen on a viscid disk which is located on the style at the point of contact. Here the pollen adheres till scraped away in the operation next to be described.

"A bee alights on the platform formed by one or more of the lower staminodia, thursts its beak forward to secure the drop of nectar, and in doing so strikes the sensitive tentacle. The pistil suddenly coils and strikes the bee. First the stigma is brought in contact, and scrapes off any pollen that may have been previously deposited on the bee at that point. Then, as the style continues coiling, it brings the viscid disk in contact with the same point of the bee's body, depositing more pollen, which will be scraped off in another flower visited. In Maranta and Calathea, the visitor is probably a bee of the size of the hive-bee, and the pollen would be deposited on the abdominal surface of its body. The visitors to the Thalia flower are of the larger bumble-bee type, and the individual receives the pollen deposit at the base and on one side of its beak. Previous to the coiling of the style, the stigma is covered by one or more of the lower staminodia; at the end of the operation, in each case, it is again covered securely, so that it has but one chance to become pollinated. After pollination, the flower rapidly withers."—WM. TRELEASE.

NEWS.

DR. W. F. R. SURINGAR, Professor of Botany and Director of the Botanical Garden at Leiden since 1862, died on July 11 at the age of 66 years.

DR. CARL FRITSCH has been appointed director of the Botanical Museum of Vienna as the successor of the late Dr. Anton Kerner von Marilaun.

PROFESSOR DR. KARL GOEBEL, director of the Institute for Plant Physiology in Munich, is absent upon a journey to Australia and New Zealand.

PROFESSOR VOLNEY M. SPALDING, of the University of Michigan, has been granted a year's leave of absence. Dr. Julia W. Snow has been appointed instructor in botany in the same institution.

PROFESSOR L. M. UNDERWOOD of Columbia University returned on October 4 from his vacation trip in Europe, where he examined many herbaria for type material of Pteridophyta and Polyporei.

MR. C. F. BAKER of the Alabama Polytechnic Institute sailed from New York on November 5 for an extended collecting tour in South America, beginning at the northern border of Columbia, the region first visited by Jussieu and Bonpland. He will touch at Jamaica on the way.

THE IMPORTANT investigations by W. Belajeff upon the male prothallia of the water ferns (Hydropterideæ), published in Russian in 1890, have been made more available to botanists in general by their republication in German. See Bot. Zeit. **56**[1]: 141–194. *pl. 2.* 1898.

THE LLOYD series of photogravures of American Fungi has been increased by the issue last month of two numbers, one of *Polyporus umbellatus* Fr., and the other of *Strobilomyces strobilaceus* Scop. The latter, showing a common species known as black boletus, is from a remarkably perfect photograph.

PROFESSOR DR. PAUL KNUTH, of Kiel, started in October from Genoa upon a scientific tour of the world. He will be absent from eight to ten months, going through India to Java, where he will remain in Buitenzorg for some time, thence to China and Japan, and finally by way of Honolulu to this country.

MR. E. W. D. HOLWAY, who spent six weeks in Mexico during September and October, has brought back many new and interesting rusts and other

fungi. He collected in the region about the city of Mexico, somewhat at Mt. Orizaba and Vera Cruz, and northward, the last stop being made at San Luis Potosi and vicinity.

PROFESSOR W. F. GANONG, of Smith College, Northampton, Mass., wishes to obtain seeds of Cactaceæ collected in the field by botanists who can vouch for the accuracy of their determinations, particularly from localities outside of the United States. They are wanted for studies upon the embryology of the family in continuation of a work upon the subject now in press. Exchange will be made if desired.

THE NATIONAL HERBARIUM at Washington recently received the entire collection made by Dr. W. H. Forwood in western Wyoming in the years 1881–2. These plants form the basis for two reports published by the War Department, both of which are now quite difficult to obtain. Many of them, also, are reported upon in Mr. Frank Tweedy's *Flora of the Yellowstone.*

THE REPORT of Dr. D. Prain, the Director of the Botanical Survey of India, for the year 1897–8, is largely occupied by a continuation of Professor Woodrow's *Flora of Western India.* He records the botanical explorations which have been made during the year, of portions of Assam and Burma; in the latter of which great assistance was rendered by Lieut. E. Pottinger, R. A.—*Nature.*

A PRIZE OF 4000 MARKS is offered by the Economic Society of Mohrungen, near Königsberg, for the best work on the relations of electricity to living organisms. This work must discuss either fundamentally new phenomena in plant or animal electricity, or, from the point of view of physics, discuss the sources of organic electricity, or its significance for life in general or for certain functions.

UNDER THE AUSPICES of the New York Botanical Garden Mr. A. A Heller will shortly leave for Porto Rico to make collections of the flora of our newly acquired territory. The flora of this island is very imperfectly represented in herbaria either in this country or in Europe. Arrangements will be made for preserving specimens both dried and in formalin. The expenses of the expedition will be borne by Mr. Cornelius Vanderbilt.

IN HIS ADDRESS before the Section of Botany of the British Association, Professor F. O. Bower, President, discusses the homology of the members of the plant body at large with special reference to the question of homology involved in the alternation of generations in green plants. The paper is one that will be of large interest at the present time. It includes, also, some suggestive remarks upon the methods to be used in terminology. Professor Marshall Ward read a paper upon Penicillium as a wood destroying fungus, in which he showed that this plant, one of our commonest molds, undoubt-

edly plays an important part in the reduction of plant offal to the vegetable mold which makes up largely the soil of our forests. It was not determined in how far the fungus could initiate the destruction of the wood, if indeed it does not merely follow the attacks of other fungi and bacteria.

EDWARD TATNALL, one of our best local botanists, died somewhat suddenly at Wilmington, Del., on the 30th of May last in his eightieth year. Almost from childhood he had strong botanical tastes, and, as these increased, they were fostered and appreciated by his association and correspondence with such botanists as Darlington, James, Gray, Engelmann, and many others. He was the author of the "Catalogue of the plants of New Castle county, Delaware," which passed through two editions. Many herbaria in this and foreign lands have been enriched by his collections. He retained his active interest in botany to the last day of his life, and his death was much regretted by all who knew him.

CARD'S *Bush fruits*, one of the "Rural Science Series," is just off the press. It is very full in botanical matter, containing descriptions of all forms of Rubus and Ribes, wild and cultivated, in North America, with very many illustrations, following, in this respect, the precedent of Fuller's *Small fruit culturist*. It also has full lists of fungi which attack blackberries, raspberries, currants, gooseberries, etc. Bailey's *Evolution of our native fruits*, just published, contains a revision, with new names, of American blackberries and dewberries. Two of Professor Bailey's works, the *Forcing book* and *Plant breeding*, are now being translated into French. They are the first American horticultural books to be republished in France.

THE BOTANICAL expedition to the LaPlata and San Juan mountains of Colorado was in the field four weeks last summer, the time being unexpectedly shortened. During that time the three collectors, Professor F. S. Earle, C. F. Baker, and S. M. Tracy, secured about 25,000 specimens. Eighteen uniform sets (all sold in advance) will be distributed shortly, beside which there will be a number of partial sets (a few yet remaining unsold). It is believed that the series is more than usually valuable, both on account of the biological importance of the region, and from the care exercised to secure all available forms and variations. There are also a number of new species, and quite a number of rare ones, including *Ranunculus Macauleyi*, in flower and fruit, *Astragalus Wingatensis*, *Cerastium arvense Fuegianum*, *Fendlera rupicola*, and others. The sets will form the basis for a report upon the season's work, to be issued with the aid of Dr. E. L. Greene.

ACCORDING TO THE *Bulletin of Miscellaneous Information* of the Kew Gardens, the duties of the new department in the West Indies to be administered by the Imperial Commissioner of Agriculture, Dr. Morris, are to induce the people, as far as possible, to substitute other industries for sugar

raising, which is the almost universal occupation. Besides this, the department is to deal with all questions concerning economic plants and the botanical stations in all the islands. For the first year a grant of £4500 was made by Parliament with the expectation that the annual charges hereafter for the department will be £17,000. The establishment of this new department is an experiment in the hope of again placing these colonies in a self-supporting condition by diversifying the agriculture. It is intended, also, that the means of communication between the islands and the markets should be greatly improved. The government purposes establishing a line of steamers between the islands and New York, and also to secure, if possible, better communication between Jamaica and London. Fortnightly communication between the different islands is also to be established. The grant for these purposes, however, is to be separate from that intended for experimental and agricultural work.

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